PETROLEUM PROCESSING

VOLUME 2, NUMBER 3 MARCH, 1947

Preheats Oil, Superheats Steam

FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

Neale

THE ATLANTIC REFINING COMPANY
GAS PROCESSING PLANT
BEAUREGARD PARISH, LOUISIANA

The completion of this liquid hydrocarbon recovery plant in the Neale Field of Southern Louisiana adds to the fund of experience of HUDSON, acquired over many years in the building of a variety of processing plants for the oil and gas industry—plants ranging in scope of products from helium to asphalt, in scope of pressures from sub-atmospheric to 12,000 pounds per square inch, and in scope of temperatures from minus 320 to plus 1500° F.

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Process design of the plant pictured was developed by the Research and Development Department of The Atlantic Refining Company. All other phases of the project including the field piping systems were developed and completed by HUDSON in collaboration with the Engineering and Construction Department of The Atlantic Refining Company.

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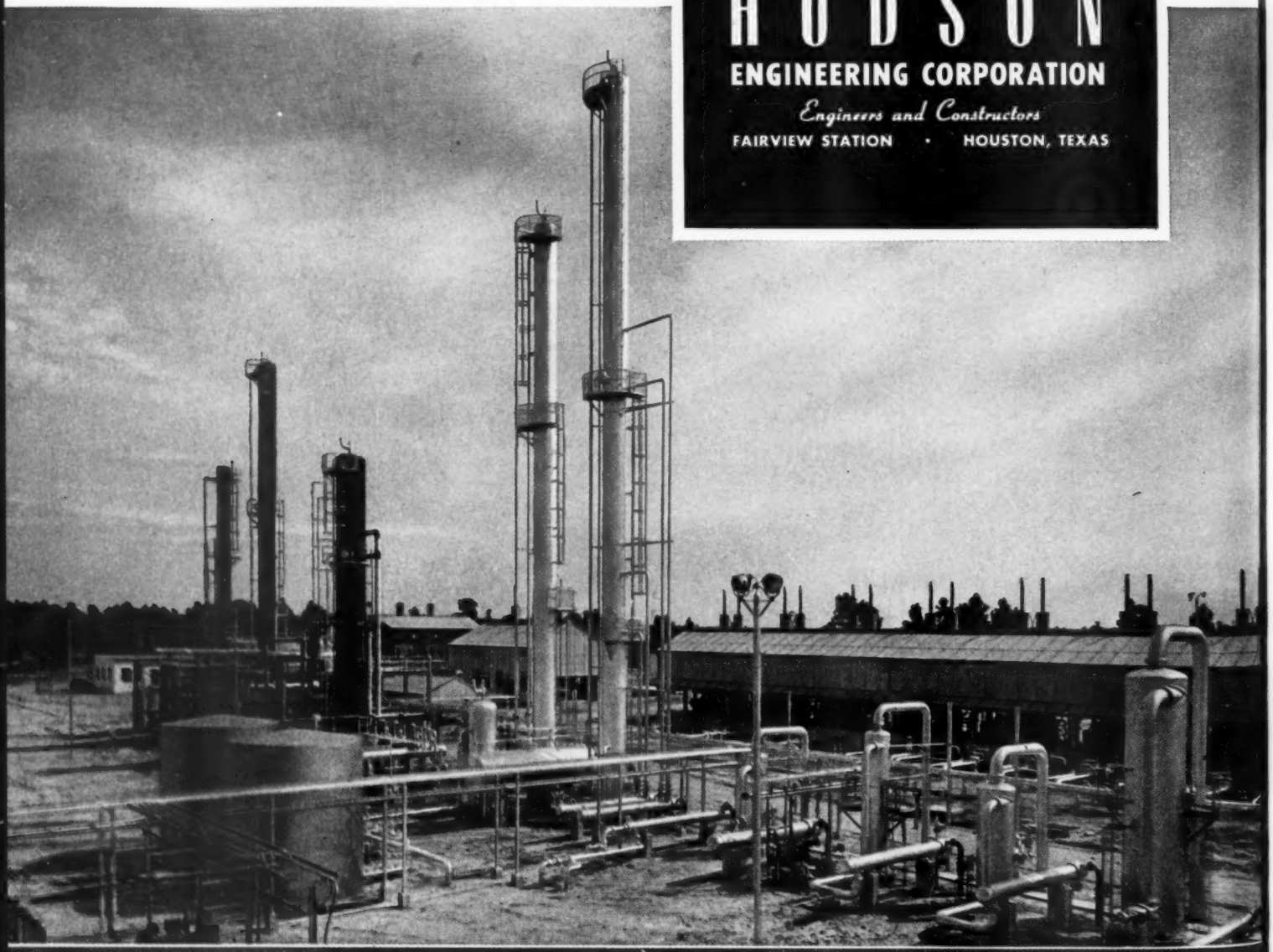


GAS COMPRESSOR STATIONS • CYCLING PLANTS • GAS DEHYDRATION PLANTS • NATURAL GASOLINE PLANTS • FRACTIONATION UNITS • CRUDE TOPPING UNITS • PRESSURE MAINTENANCE PLANTS • HYDROGEN SULPHIDE REMOVAL PLANTS • ATMOSPHERIC AND VACUUM DISTILLATION UNITS

A "Switchboard"-type system with quick-coupler connections facilitates the transfer and blending of experimental fuels among the thirty-four underground tanks at Ethyl's Detroit Laboratories.

Fuel research involves many gasolines

AT THE Ethyl Research Laboratories, fuel base stocks containing different types of hydrocarbons are selected from many sources of crude petroleum and from many refining processes. These base stocks are used as components of experimental gasolines for research on fuels for engines of present and future design. Depending on the nature of the investigations to be made, "Ethyl" antiknock compound or experimental antiknock agents are added to the resultant gasolines in sufficient quantities to meet desired antiknock values. Certain compounds may also be included to inhibit the formation of gummy oxidation products during storage.

The handling of this wide variety of constituents for research fuels, blending them into finished gasolines and storing them prior to use are accomplished at the Ethyl laboratories with specially designed equipment. Other specialized equipment is used in the laboratories and in road test cars in determinations of the characteristics and performance of these fuels as one of the services to the oil and automotive industries.

Blending gasolines for research use and fitting them to engines is a part of the work of these laboratories, which are designed for research on the complex interrelationships among engines, fuels and lubricants and their additives. For cooperative investigations of these interrelationships, special fuels often are supplied to engine manufacturers.

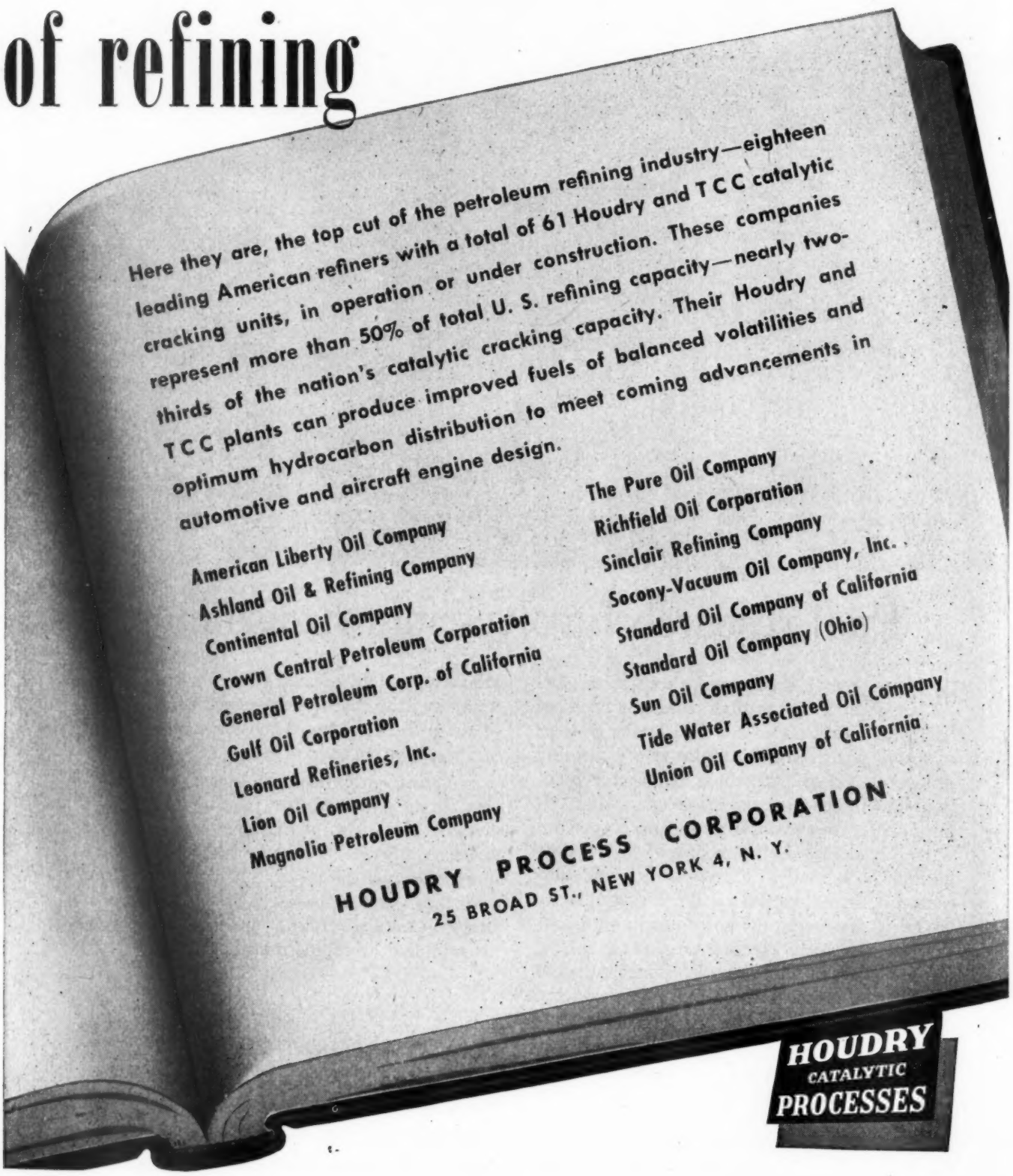
ETHYL CORPORATION

research laboratories

1600 West Eight Mile Road, Detroit 20, Michigan

2600 Cajon Road, San Bernardino, California

The list of Houdry licensees is the Blue Book of refining


Here they are, the top cut of the petroleum refining industry—eighteen leading American refiners with a total of 61 Houdry and T C C catalytic cracking units, in operation or under construction. These companies represent more than 50% of total U. S. refining capacity—nearly two-thirds of the nation's catalytic cracking capacity. Their Houdry and T C C plants can produce improved fuels of balanced volatilities and optimum hydrocarbon distribution to meet coming advancements in automotive and aircraft engine design.
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PUBLICATION OFFICE

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PETROLEUM PROCESSING

Of Crude Petroleum and Natural Gas
For Fuels, Lubricants and Petrochemicals
REFINERY OPERATION, MAINTENANCE, EQUIPMENT, DESIGN

FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

COMING MEETINGS

March

17-19, American Society of Lubrication Engineers, National Convention, William Penn Hotel, Pittsburgh.
17-19, American Institute of Mining and Metallurgical Engineers, 75th Annual meeting, Waldorf Astoria, New York City.
22-28, American Society for Metals, 5th Western Metals Congress and Exposition, Civic Auditorium, San Francisco.
24-26, Western Petroleum Refiners Assn., 35th Annual membership meeting, Plaza Hotel, San Antonio.
27-29, American Petroleum Institute, Southwestern District, Blackstone Hotel, Ft. Worth.
31-April 2, Midwest Power Conference, Palmer House, Chicago.

April

7-10, National Association of Corrosion Engineers, Convention meeting, Palmer House, Chicago.
9-11, Society of Automotive Engineers, Aeronautic meeting, Hotel New Yorker, N. Y.
14-18, American Chemical Society, 111th National meeting, Atlantic City, N. J.
17-18, National Petroleum Association, Semi-annual convention, Hotel Cleveland, Cleveland, Ohio.
23-25, Natural Gasoline Association of America, 26th Annual convention, Baker Hotel, Dallas.
30-May 2, American Gas Association, Spring meeting, Stevens Hotel, Chicago.

May

12-17, South American Petroleum Council, Lima, Peru.
17-24, International Petroleum Exposition, Tulsa.

June

15-20, American Society of Mechanical Engineers, Annual meeting, Chicago.
16-20, American Society for Testing Materials, 15th Annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

THIS MONTH'S COVER . . .

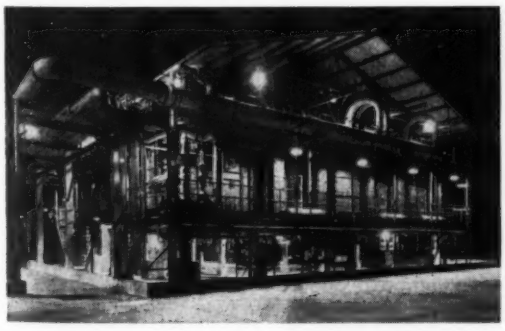

Photo courtesy Shell Oil Co.

This four-cell Foster Wheeler furnace at Shell's new Fluid Catalytic Cracking unit not only preheats charge stock but also superheats steam. Three cells at the left heat feed to 820-825° F., one on right superheats wet steam produced from waste heat in the unit, at rate of 165,000 lbs./hr. of 225-psi steam. Engineering details of the Shell Fluid unit, the first designed to operate on microspherical catalyst, are given in this issue of PETROLEUM PROCESSING, pg. 173

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★ Exclusive in *PETROLEUM PROCESSING*

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New

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PETROLEUM PROCESSING
MARCH, 1947

Photo courtesy Pennsylvania Dept. of Health

Liquid ammonia discharged as waste from the wax plant of a refinery killed these fish—two tons of them, varying in length from 2 to 30 in.—when approximately 250 gals. of 20%-concentration ammonia were dumped near a creek while the plant was being repaired. Suit against the company was dropped when it replaced the fish

Refinery Wastes Face Stricter Control In Pending Anti-Pollution Legislation

WASHINGTON

ANTI-POLLUTION legislation which would give the Federal government control over the disposal of refinery and other industrial wastes stands a good chance of being passed by Congress this year. The Federal government could step into the picture, however, only in cases where an individual state did not itself meet a pollution problem.

At present the only Federal law designed to prevent pollution is concerned with oil. It was passed originally in 1924 to prevent pollution by the discharge of oil from vessels, but has since been interpreted to cover oil discharged as waste from refineries and other land plants. No law gives the Federal government jurisdiction over any other types of refinery wastes.

Six bills pertaining to stream pollution have been introduced so far. If approved, they will affect refinery waste disposal plans in one or more of four ways.

1—The U. S. Public Health Service would be empowered under certain conditions to bring court action to prevent the pollution of interstate waters.

2—Federal aid in the form of loans would be made available to industrial enterprises for planning and constructing

By WILLIAM F. BLAND
Engineering Editor
PETROLEUM PROCESSING

treatment facilities to prevent pollution.

3—No new sources of pollution would be permitted to be discharged into any interstate water without the approval of the state health authority.

4—Expenditures for planning and constructing facilities for the treatment of industrial wastes would be allowable as deductions in computing net income for tax purposes.

Four Bills on Pollution Control

Four of the six bills pertain to control of pollution: H. R. 123, introduced by Rep. Karl E. Mundt (R.-S.D.); H. R. 315, by Rep. Brent Spence (D.-Ky.); H. R. 470, by Rep. Charles H. Elston, (R.-Ohio), and S. 418, by Senators Alben W. Barkley (D.-Ky.) and Robert A. Taft (R.-Ohio).

The other two bills are concerned with the tax deduction proposal: H. R. 1047, introduced by Rep. John Kee (D.-W. Va.), and S. 244, by Senator Harley M. Kilgore (D.-W. Va.).

All of these bills so far have only been referred to committees, the control bills to their respective Committees on Public Works, and the tax bills to the Ways and Means Committee in the House and the Finance Committee in the Senate.

Why Action Is Predicted

Several reasons are advanced by those familiar with the subject as to why they think something will be done this year—after all previous efforts to bring the Federal government more aggressively into the pollution picture have failed.

For one thing, they point out, there is less controversy this year. In previous years there have been two opposing schools of thought—one which wanted "penalty" bills passed (calling for strict Federal enforcement of anti-pollution measures), and one which wanted only "study" bills (no Federal enforcement, merely study and investigation of the problem). All of the four bills on stream pollution so far introduced are basically "penalty" type bills, although they also provide for study.

Another factor which is said to indicate that action will be taken this year is the fact that one group of bills has bipartisan support in both the Senate and the House—the Spence and Elston bills

(H. R. 315 and H. R. 470) and the Barkley-Taft bill (S. 418).

As the Washington representative of one industrial association told PETROLEUM PROCESSING, "It looks like the boys on the Hill have gotten together!"

Also a factor—and perhaps the primary motivating one—is public opinion. Prior to the war the clamor against indiscriminate dumping of wastes had risen to the point where action was imminent, but the pressure of wartime production caused the shelving of most anti-pollution plans—both at the Federal level and in industry.

Today industry is getting back to normal production, materials are again becoming available—and the clamor is increasing in crescendo, even though it isn't music to industry. Congress, public opinion to the contrary, pays attention to public opinion.

Three Bills are Identical

The three bills on pollution control which have bipartisan support (Spence, Elston, Barkley-Taft) are identical word for word. The Spence bill, which was introduced first, will be discussed here as representative of all three.

The Surgeon General of the Public Health Service, according to the Spence bill, would have the responsibility and authority for carrying out the proposed anti-pollution program, under the supervision and direction of the Federal Security Administrator. The bill also establishes a 9-man Water Pollution Control Advisory Board, chairmanned by the Surgeon General or a sanitary engineer officer designated by him, and including representatives of the War, Interior and Agriculture Departments (one each) and five non-Federal employees or officers appointed annually by the Surgeon General. This board would review the policies and program of the Public Health Service on pollution control and make recommendations.

The Spence bill includes provisions for the study and investigation of pollution, and the preparation of plans for eliminating pollution and improving the sanitary condition of industrial wastes. It encourages uniform state pollution laws and the establishment of interstate compacts to combat the problem.

The bill states that it is "the policy of Congress to recognize, preserve and protect the primary responsibilities and rights of the States in controlling water pollution, and to provide Federal technical service and financial aid. . ."

However, the bill also gives the Surgeon General the authority to step in when a state doesn't meet the problem and to bring court action to enforce pollution abatement.

According to Section 2 (d) of the proposed law, "Whenever it is found that the pollution of interstate waters in or adjacent to any state or states is such that in the opinion of the Surgeon General . . . the health or welfare of citizens of the U. S. is being jeopardized, the Surgeon General may give formal notification thereof to the appropriate State health authority or interstate agency. This notification may outline recommended remedial measures which are reasonable and equitable and shall specify a time regarded by the Surgeon General as reasonable to secure the abatement of the pollution.

"If action to abate such pollution is not taken within the time specified, this failure shall again be brought to the attention of the appropriate State health authority or interstate agency and may be accompanied by a recommendation that suit to abate the pollution be initiated forthwith by such State health authority or interstate agency in a court of proper jurisdiction.

"If such suit is not initiated within a reasonable time, not to exceed two years, an *action to abate such pollution shall then be brought in the name of the U. S.* (italics ours) by any U. S. attorney when requested to do so by the Surgeon General. Such action shall be brought as an action in equity, and may be brought in any court in the U. S. having jurisdiction to hear and determine equity cases."

It is this section on enforcement in the Spence bill which is significant to those who have followed previous attempts to put anti-pollution laws into the Federal statutes. All previous bills on pollution introduced by Rep. Spence (this is his fourth) have been the "study" type and have not called for Federal enforcement.

Funds Povided for Loans

The Spence bill also provides for Federal aid in the forms of loans to industrial enterprises for the construction of necessary treatment works and the preparation of engineering reports, plans and specifications for them. It authorizes the appropriation of not more than $100,000,000 annually for such loans and for grants-in-aid to state, municipal and other public bodies for such work.

Such loans would be made through the Federal Security Agency and would be subject to the following limitations:

1—They would be made only with respect to projects approved by the appropriate State health authority and by the Surgeon General.

2—They would have to be "fully and adequately secured" and would bear interest at the rate prescribed by the President.

3—Each loan would be made for a period not exceeding ten yaers.

An additional $1,500,000 would be made available annually to individual States and interstate agencies for investigations and studies by them of pollution conditions and their prevention and control.

It should be pointed out that the Surgeon General would be authorized to carry out study and investigation programs on *any* surface or underground waters in or adjacent to any State, although Federal action in abating pollution would be restricted to *interstate* waters in or adjacent to any State or States.

Interstate waters are defined in the bill as meaning "all rivers, lakes, and others waters, and their tributaries, that flow across, or form a part of, State or international boundaries."

Mundt Bill Prevents New Pollution

The Mundt bill (H. R. 123) is pretty much identical with the Spence bill, except for two very important differences.

It is more strict in one respect: it states that "no new sources of pollution shall be permitted to be discharged into interstate waters without approval of the State health authority made in compliance with regulations prescribed by the Surgeon General."

It also takes into account, however, the fact that in some cases there might not be any known method of combatting or controlling a pollution condition except to close up the industry causing it, which might make the cure worse than the disease.

To get around this objection, the Mundt bill (which contains a section 2 (d) similar to that described above for the Spence bill) provides further that:

"Notwithstanding the provisions of section 2 (d), if, after public hearing, the Water Pollution Advisory Board finds that it is impossible or impracticable for any industry or any municipality or other public body to comply with the regulations prescribed under section 2 (d) establishing minimum requirements as to treament of any waste or substance either because no adequate or practical method of disposal or treatment is known, . . . the Surgeon General shall not cause an action to be brought to prevent or abate the discharge or deposit of such waste or other substance into the waters covered by this act by such industry or municipality or other public body during such period of time not in excess

State Engineers

Do you know to whom you can write for information on pollution legislation in you state or in other states affected by your plant's operations? Through the cooperation of the U. S. Public Health Service, PETROLEUM PROCESSING has secured a list of the engineers in charge of public health engineering activities in all state departments of health. A copy of this list will be sent without charge upon request to the Reader's Service Dept. of PETROLEUM PROCESSING, 1213 West Third St., Cleveland 13, Ohio.

of five years as the Water Pollution Advisory Board determines is necessary in order to provide means for the disposal or treatment of such waste or other substances so as to comply with such regulations.

"Extensions of time beyond such five-year or shorter period may be granted by the Surgeon General after public hearing, if the industry or municipality or other public body involved shows to the satisfaction of the Water Pollution Advisory Board that it has diligently tried to comply with such regulations."

One Other Difference

There is one other difference between the Spence and Mundt bills, small but highly important in determining which bill, if either, will be passed. The Spence bill states that the loans and grants-in-aid should be made "upon such terms and conditions as the *President* may prescribe," whereas the Mundt bill designates *Congress* as the agency to set the terms and conditions.

This fundamental difference of opinion as to which branch of our government is to handle such functions has long been a factor in pollution legislation, and was the primary reason why the late President Roosevelt in 1938 vetoed the only anti-pollution bill to be approved by both Houses since the Oil Pollution Act of 1924.

In his veto message concerning that bill, the Vinson bill, the President stated that it provided for "the legislative assumption of responsibilities of the executive branch, and, therefore, runs counter to the fundamental concept of our Budget system, that the planning of work programs of the executive agencies and their presentation to Congress in the form of estimates of appropriation is a duty imposed upon the Chief Executive and not one for exercise by the legislative branch."

The Vinson bill was strictly a "study" type bill. It would have provided Federal funds for study and investigation, and for loans and grants-in-aid. It would have placed responsibility for a water pollution abatement and prevention program in the Public Health Service, but it did not contain any provisions for Federal enforcement of the program.

Would Make Costs Tax-Deductible

Two of six bills mentioned in the first part of this article are concerned with making waste treatment costs tax-deductible—the Kilgore bill (S. 244) and the Kee bill (H. R. 1047). Both are identical or companion bills, one being introduced in the Senate and the other in the House.

Each is entitled "A bill to encourage the prevention of stream pollution by allowing amounts paid for plants for the treatment of industrial wastes as a deduction in computing net income."

They provide for an amendment to that section of the Internal Revenue Code pertaining to allowable deductions in computing net income, and state that "amounts paid during the taxable year for the construction of facilities" for the treatment of industrial wastes discharged directly or through public sewage systems into rivers or streams of the U. S. shall be considered as a deductible item. According to the bills, these expenditures can include the cost of "plans for such construction and treatment."

These expenditures would be deductible, however, only with respect to the taxable years beginning after Dec. 21, 1947, and before Jan. 1, 1954.

Such expenses, involving, as they do, the construction of permanent buildings and equipment, would usually be considered as capital expenditures, and as such would not be allowed as a deduction.

Present Federal Laws Are Meager

At the present time there are only two Federal laws which affect pollution and industrial waste disposal—the River and Harbor Act of 1899 and the Oil Pollution Act of 1924. Both of these acts are administered to prevent pollution by oil.

The 1899 Act was originally passed to prevent shoaling by the discharge of solids into navigable waters, and to prevent other forms of interference with navigations. Later court decisions extended the scope of this act to include oil as a substance which interfered with navigation.

The 1924 Oil Pollution Act is the only anti-pollution law on the Federal statute books today. Although it applies specifically to vessels which pollute navigable waters with oil, it has been used under certain conditions in bringing orders and prosecutions against land plants causing oil pollution.

Many attempts have been made, however, to strengthen the Federal position on pollution, and during the past 25 years nearly a hundred bills (if not more) have been introduced. Most of them died in committee. One of them, the Vinson bill, discussed previously, got as far as the President and was then vetoed. Last year the Mansfield bill (H. R. 6024) was approved by the Committee on Rivers and Harbors. It was thought at the time to have a good chance of passage, but was never taken up by the House.

The Mansfield bill was similar in many respects to the present Mundt and Spence Bills. It differed in some administrative procedures, however, and would have provided closer control of pollution by the Federal government.

It authorized the Surgeon General to set up sanitary water districts, prescribe regulations for each of them, and establish standards of cleanliness for the navigable waters in them. It also declared that the discharge or deposit in violation of those regulations of any waste or other substance (in solid, gaseous or liquid state) injurious to human health or any form of life was against the public policy of the U. S. and a "public and common nuisance." It empowered the Surgeon General to bring court action to prevent or abate pollution within six months after written notice had been given of the existence of the condition.

State Activity Increasing

Perhaps fearful of having the Federal government step in and tell them how to clean up pollution conditions, the States during the past few years have been directing more and more attention to the problem. Evidence of that trend was uncovered in a survey of state pollution abatement progress made recently by the magazine *Sewage Works Engineering*.

In that survey it was reported that "Pollution legislation is definitely in the making throughout the nation." Most states already have anti-pollution legislation of some sort on their books, although, the survey states, "the potency of some of these laws is open to some doubt and needs strengthening." Many of the states covered in the survey had just recently passed new or revised anti-pollution measures, or were planning such action in the very near future.

Also brought out in the survey was the fact that "industries are willing and ready to correct industrial waste pollution," according to the statements of state sanitary engineers. "States are meeting with individual industries and industrial groups not as policemen but as cooperators, as both sides are beginning to realize that trade waste disposal is an important problem. The unanimity with which states agree that industry is cooperating is highly impressive."

Copies of Bills

Four bills pertaining to the control of industrial wastes have been introduced in Congress so far this year:

H. R. 123, Rep. Karl E. Mundt (R.-S.D.).

H. R. 315, Rep. Brent Spence (D.-Ky.).

H. R. 470, Rep. Charles H. Elston (R.-Ohio).

S. 418, Senators Alben W. Barkley (D.-Ky.) and Robert A. Taft (R.-Ohio).

Two bills introduced would make the cost of treatment plants a deductible item for tax purposes:

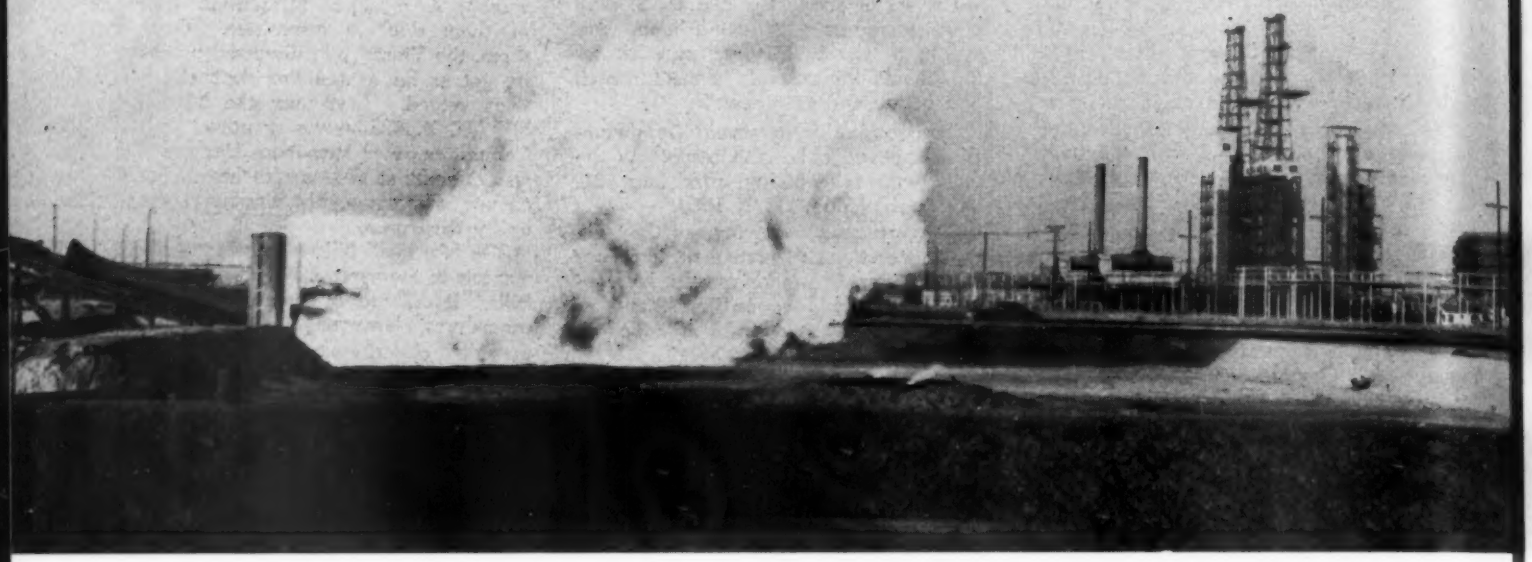
H. R. 1047, Rep. John Kee (D.-W. Va.).

S. 244 (Senator Harley M. Kilgore (D.-W. Va.).

Single copies of these bills can be obtained without charge by writing to the Reader's Service Dept. of PETROLEUM PROCESSING, 1213 West Third St., Cleveland 13, Ohio.

WASTE DISPOSAL

SMOKELESS BURNING OF VENT GASES



By A. K. BRUMBAUGH
General Petroleum Corp.

Objectionable smoke has been eliminated in the disposal of waste light hydrocarbon gases at the refinery of General Petroleum Corp. at Torrance, Cal., through a specially designed installation of venturi-type aspirating burners. Four automatically-controlled burners can dispose of as much as 14 million cu. ft./day of waste gas if required.

MANY refineries located in metropolitan areas face a severe problem in the disposal of waste light hydrocarbon materials, especially those gases and liquids which are discharged from safety relief valves and which consequently are produced in widely varying amounts not subject to direct control.

This is particularly true of operations involving large gas-recovery, light-end fractionation, and alkylation units; for such equipment requires holding in process vessels considerable volumes of hydrocarbons. The special problems associated with materials in the propane-hexane range result from a combination of volatility at normal temperatures and vapor density appreciably greater than that of air. The high volatility means that discharged material may not be readily condensed, for example by water washing, and the high vapor density slows down dispersion by natural forces and encourages the formation of pockets of gas.

Most operators of this type of equipment have concluded that the only safe method of handling such vented material is burning. Early in 1946 General Petroleum Corp. instituted a program aimed at the development of equipment which would burn vent gases without objectionable smoke.

As a first step a careful search of the literature was made but no reports of any approach to the problem were found. Without previous background, various methods of supplying and mixing air with the gas prior to ignition were studied with the result that the design of a venturi type aspirating burner was attempted. Mechanical methods of aeration, for example by blowers, had to be ruled out because the volumes of gas to be handled were so great as to require equipment of prohibitive size. Information for the design of the experimental unit shown in Fig. 1 was obtained from three sources given in the bibliography and this unit was set up for field tests.

It was found that isobutane vapors could be burned without smoke using a ratio of venturi throat area to gas orifice area of 4 to 1. When isobutane containing considerable amounts, possibly 20%, of unvaporized material was fed to the burner it was necessary to substitute a smaller gas orifice, thereby increasing this ratio to 16 to 1. With the 16 to 1 ratio the wet material burned without smoke, this despite the fact that liquid could be seen emerging from the burner mouth and entering the flame. Wet gas from the gas plant feed required a ratio of 8 to 1 for clean combustion. It was also determined that with the orifice ratio giving minimum satisfactory aeration the pressure upstream of the gas orifice could be reduced to ⅛ psig. without flame popping back. Below this limit operation was unstable; eventually the flame would travel back through the venturi tube and burn at the gas orifice. It was discovered however that a pressure of about 1 psig. would blow the flame through the tube and re-establish normal operation.

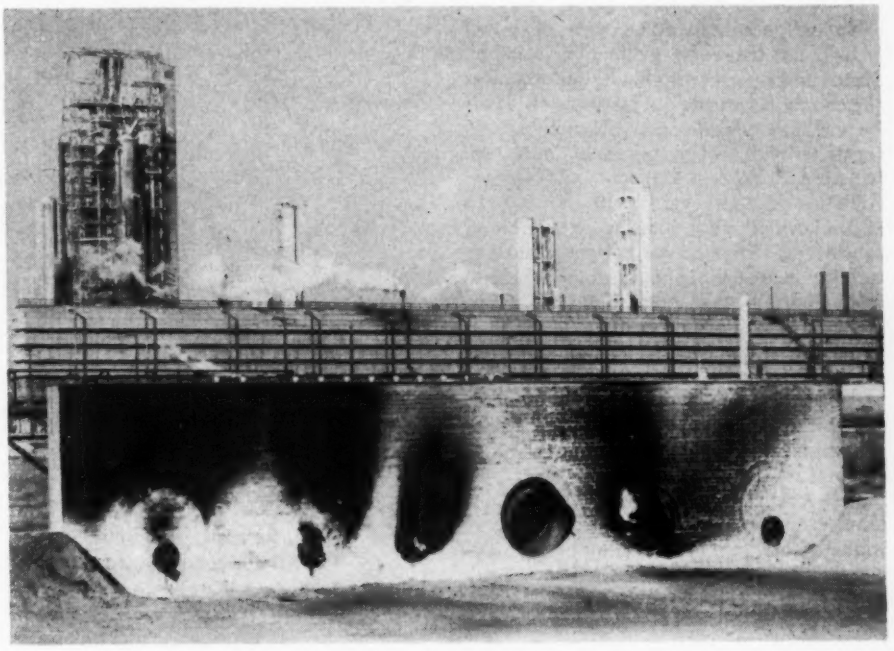
With the limitations of the venturi burner established, the application of such units to the refinery flare system was considered. As it was apparent that the permissible pressure at the gas orifice would control the size of the equipment, calculations were made to determine the effect of this back pressure on the relief valve system, with the result that 5 psig. was chosen as the maximum figure. Because all the vessels tied into the burner system had design pressures of 100 psig. or over, and the relief piping was adequately sized, it was found that for any reasonable assumption of emergency conditions the pressure rise in the protected vessel or vessels would be well within the margin of allowance set by the API-ASME Code. The effect of back pressure on the popping pressure of the relief valves could be ignored, as the greatest build-up at the downstream side of any valve was estimated at 15 psig. while the set pressure was at least 25 psig. below the design pressure of the vessel in question. It was also decided to design the burner installation for a rate of 14 million cu. ft./day, this seeming sufficient to handle any discharge resulting from emergencies.

With an operating pressure range of ¼ psig. to 4 psig., a given gas orifice would have a range of volume burned of 4 to 1. As the volume to be handled could be expected to vary from zero to the maximum it was decided to employ several burners of varying sizes with

some sort of pressure responsive mechanism to cut them in successively. A conventional back-pressure control valve could not be used for this purpose for as soon as the burner was turned on the increased flow would drop the header pressure with the result that the valve would quickly shut off again, resulting in a cyclic intermittent action. To meet this problem an adaptation of commercially available control valves was made as shown in Fig. 2. With this mechanism adjustment, one pilot valve sets the opening of the main valve at any desired header pressure while the other pilot valve permits adjustment of the closing point to that pressure on the burner orifice which is the minimum for satisfactory operation.

A schedule of opening and closing pressures was set up for the series of burners, arranged so that the largest unit would be the last to cut in and the first to cut out. The size of the smallest burner orifice was next determined, being estimated from the surge capacity of the entire piping system and the normal amount of vapor leakage so that this burner would operate at fairly infrequent intervals to discharge accumulated material. The size of the next larger orifice was calculated from that of the smallest and the operating pressure schedule, being limited so that both burners at the cutout pressure of the second would burn only as much gas as the first burner alone at the cut-in pressure of the second.

It will be seen that this method of graduation provides a stable operating condition for any gas flow in the range covered, thereby avoiding intermittent operation. Other gas orifices were determined maintaining a similar relationship between the capacity of each additional burner and the total of those which would have previously cut in. Venturi tube dimensions were established by direct proportion to the experimental unit which had given good results, selecting

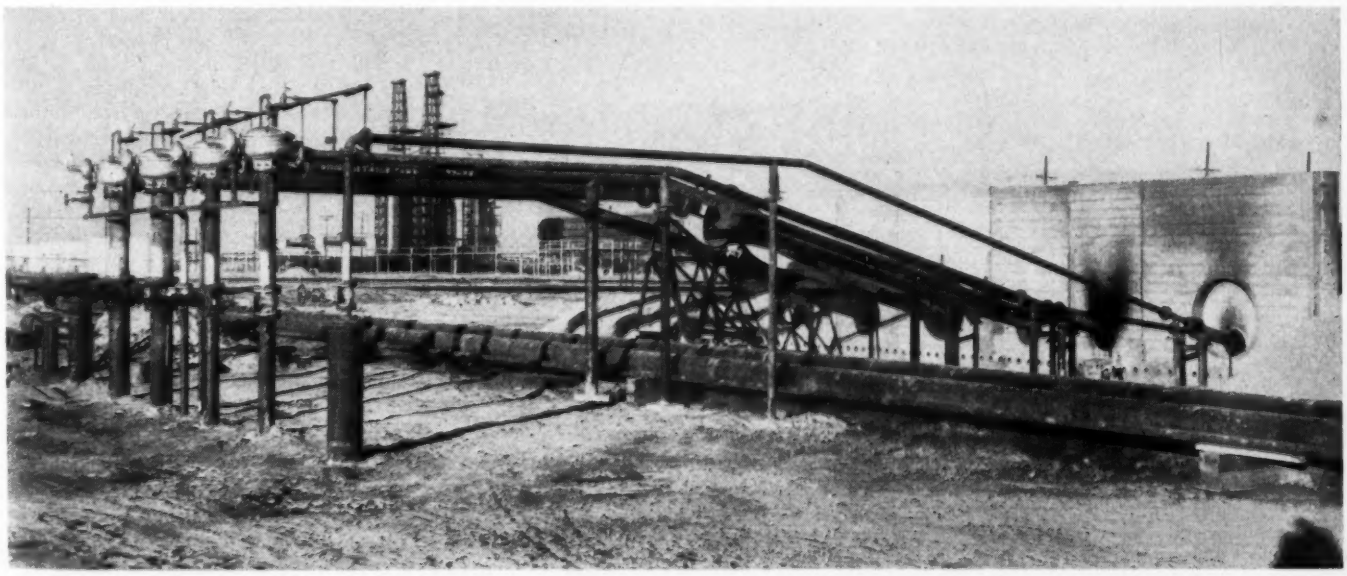


Concrete and fire-brick wall which is the setting for the burners, as seen from the sump side of the installation. Differences in diameters of venturi tubes can be readily seen. The sump or burning area is banked on all four sides by an earthen wall about 4 ft. high, and is located well away from refinery processing units

TABLE 1—Size and pressure Data for Burners in Waste Gas Disposal Installation

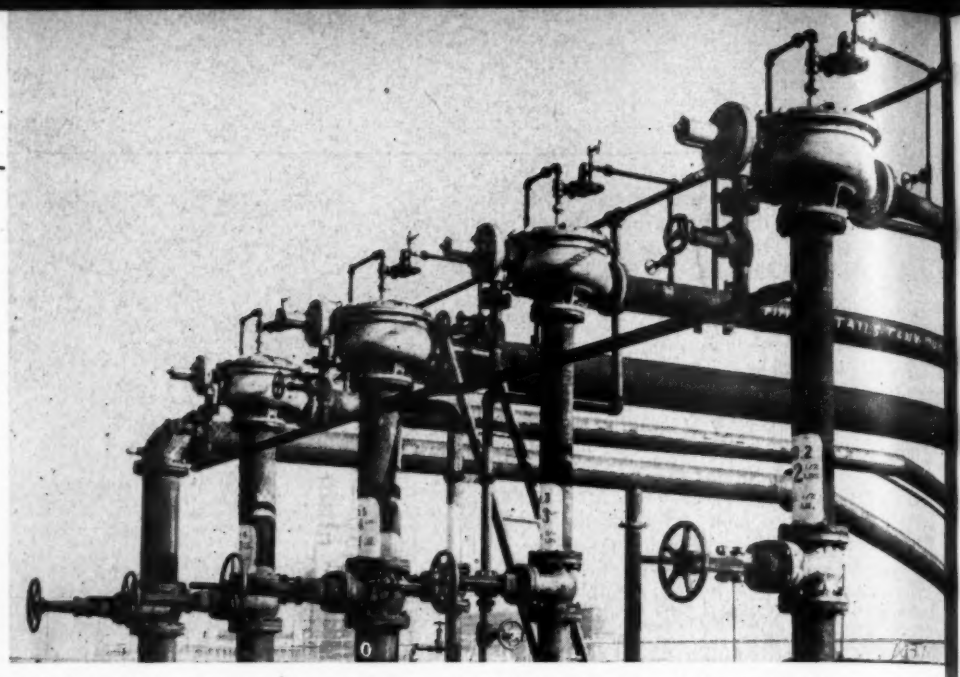
Burner Number	Cut In psi.	Cut Out psi.	Gas Orifice Dia., In.	Venturi Throat Dia., In.	Ratio Throat Area to Orifice Area
1.	2¼	¼	1.61	5	9.6
2.	2¾	½	2.9	8	7.8
3.	3¼	¾	4.03	11.5	8.1
4.	3¾	1	7.0	18	6.6

Regulator manifold and piping to burners. Vertical lines at left rise from a 36-in. diameter underground gas header. The four regulators at the tops of these lines open and close in sequence under increasing volumes of waste gas. Venturi tubes of correspondingly increasing dimensions and capacities may be seen in the fire wall at the right



a venturi area to orifice area of about 8 to 1 as the most generally desirable. Sizes and pressures finally used after slight readjustments to conform to readily vailable material and after field tests together with other pertinent data are included in Table 1.

To convey the vapors to the battery of burners all vent lines were combined in a 36 in. diameter underground header, each burner having an individual riser to its control valve. Provision was made for continuous drainage of condensate, all vents were pitched from the relief valve to the header from whence a sealed gravity drain conducted liquid to the refinery recovery system. Because lack of capacity or failure of the automatic valves to operate might impair the functioning of the entire relief system, a branch of the main header was led to a water seal where its open end was submerged beneath 10 ft.-4 in. of water, resulting in assured release of vapors at header pressures over 4½ psig.



Each of the four automatic regulators, adapted from commercially available control valves, includes two pilot valves, one setting the opening of the main valve, the other permitting adjustment of the closing point

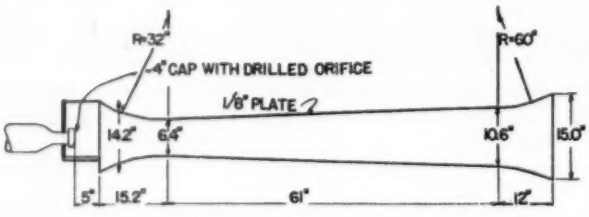


Fig. 1 — Simplified sketch of experimental burner and venturi tube used by General Petroleum Corp.

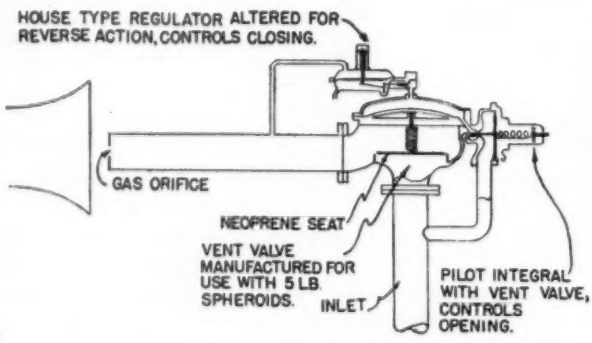

HOUSE TYPE REGULATOR ALTERED FOR REVERSE ACTION, CONTROLS CLOSING.
GAS ORIFICE
NEOPRENE SEAT
VENT VALVE MANUFACTURED FOR USE WITH 5 LB. SPHEROIDS.
INLET
PILOT INTEGRAL WITH VENT VALVE, CONTROLS OPENING.

Fig. 2—Burner control mechanism showing the two pilot valves. One controls the closing of the main valve, the other controls the opening of the main valve

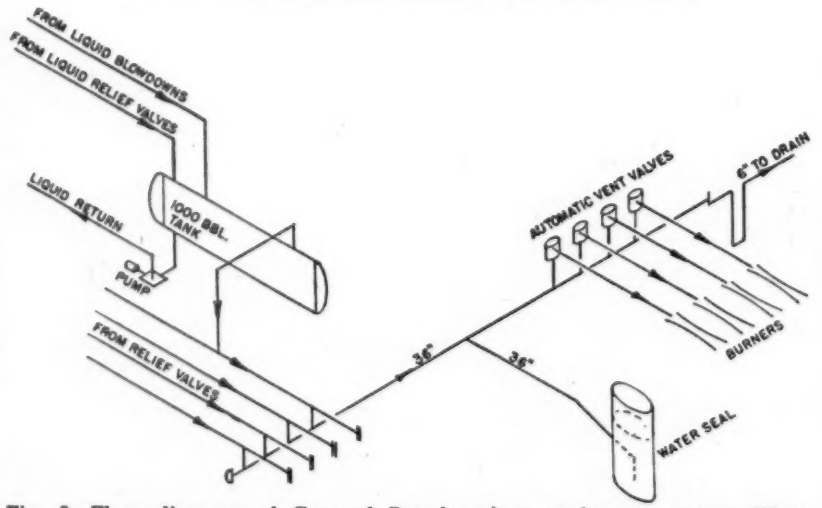


Fig. 3—Flow diagram of General Petroleum's vent burner system. Waste gases from liquid blowouts are collected in 1000-bbl. accumulator at left, then join other waste gases in 36 in. header

In order to avoid liquid hydrocarbons reaching the burners, as well as save valuable material for re-use, discharge lines from relief valves of all vessels operating full of liquid, and hand controlled drains from reflux drums and the like were segregated and led to a 10 ft. dia. by 78 ft. long accumulator which in turn was connected to the burner header. Liquid trapped in this vessel can be pumped back to the plant for recovery.

Experience with previous simple flare installations indicated that arrangement of the burner setting to provide satisfactory service life despite the tremendous evolution of heat during an emergency would require serious consideration. Experiments with the first unit showed that the aspirated air kept the venturi tube itself relatively cool so it was thought that if provision were made to protect the burners from radiated heat and flame from adjacent units, fabricated steel venturis could be used. Thicknesses varied from ¼ in. for the smallest sizes to ½ in. for the largest. An air cooled wall 10 ft. high and 50 ft. long was constructed and the burners were installed flush with the surface through suitable ports. The wall consists of a 13 in. face of firebrick, a 2 in. air space, and an 8 in. thick reinforced concrete backing. Pipe nipples through the concrete along the bottom provide for convection circulation of air through the clearance space. All of the separate elements of this installation are coordinated in the flow chart Fig. 3. Various photographs of the equipment are included in the interest of clarity.

Bibliography

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U. S. Bureau of Standards, Circular 394

U. S. Bureau of Standards, Technical Paper 193

TOMORROW

...IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **Announce accelerated production of petroleum chemicals.**
- **Men, motive, and money in industrial research.**
- **Colleges make varied charges for industrial research.**
- **Distillation bibliography of value to petroleum engineers.**
- **Government research on Synthine process proceeds rapidly.**

Industry Speeds Production Of Petroleum Chemicals

SCARCELY a day now passes that some company does not announce plans to produce some chemical from petroleum or to augment its current program in that field. Prominent in the recent news are such major chemical producers as du Pont, Carbide and Carbon, Celanese, Rohm & Haas, Koppers, and Oronite. Another organization, Standard of New Jersey, has recently centered all the sales and distribution activities of its chemical subsidiaries in a new concern, Enjay Co., Inc.

By its own admission, du Pont will add nylon to the list of plastics from petroleum when a new adipic acid unit at its Sabine River (Texas) works comes into production sometime this year. Even before its completion, du Pont has applied for CPA approval for an additional adipic acid unit.

Carbide and Carbon will shortly begin the construction of units for the production of Vinylite resins as an addition to its chemical plant at Texas City, Texas. Other parts of its $15,000,000 general building program, initiated in 1945, include units for the production of butyl alcohol, ethyleneamines, and "extensions designed to increase capacity for industrial organic solvents and antifreeze compounds" (probably ethylene oxide, ethylene glycol, and their derivatives).

Early this year, the Celanese Chemical Corp. began the commercial production of *n*-propyl alcohol and *n*-propionaldehyde at its plant near Bishop, Texas. Both of these new petroleum chemicals are expected to find wide use as solvents and chemical intermediates.

A new petroleum chemicals plant is scheduled for construction on the Houston Ship Channel, Deer Park, Texas, by the Rohm & Haas Co. No details are yet available, but this company already operates plants at two Pennsylvania sites and at Knoxville, Tenn. Products include chemicals for the textile, plastics, leather, and insecticide industries.

The Oronite Chemical Co. is installing additional units at the Richmond, Calif., refinery of Standard Oil of California (its parent company) for the manufacture of "Oronite Detergent," an alkyl aryl sulfonate surface-active agent said to be produced entirely from petroleum. Present production, in the form of slurry and powder, is said to approximate 100,000,000 lbs per year. The detergent may eventually be sold in cake form.

Plans for the construction of a chemical plant to produce aromatic and unsaturated hydrocarbon chemicals, including benzene and styrene, have been announced by the McCarthy Chemical Co., which already operates a natural gasoline plant at the chosen site, Winnie, Texas. The first unit will cost in excess of $3,000,000. Glenn H. McCarthy, the Houston operator involved, recently made a $9,100,000 offer for the Government owned styrene plant at Texas City.

All of this activity is interesting in itself, but it is far more important as an indication that the snowball of petroleum chemicals production is continuing to roll downhill. From all signs, to mix a metaphor or two, many more companies will be jumping on the bandwagon.

Men, Motive, and Money In Industrial Research

INDUSTRIAL research is a business in itself, as evidenced these days by the rapid increase in the number and size of industrial research laboratories. Just as in other businesses, also, good management and a clear conception of purpose are necessary for success. "Industry not only has a large stake in industrial research, but a continuing problem in the coordination of research motives or objectives, the manpower engaged in research activities, and the supporting money."(1)

For these reasons, a recent survey(1) of organization and business practices in the field of industrial research, conducted by the Standard Oil Co. of Calif., is of considerable interest to the petroleum industry (several of whose member companies contributed to its preparation) and to industry in general.

Space does not permit discussion of the many subjects included, but the following list of industrial research motives is too clear to consider its omission: "Modern industry turns to research to accomplish the following objectives: (1) to cure existing troubles and nuisances in connection with materials, processes, products, and services, and to anticipate and prevent such troubles; (2) to reduce the costs involved in the use of materials, processes, products, and services; (3) to improve the quality of existing materials, products, and services; (4) to reduce the customer's operating and maintenance costs; (5) to develop new uses for existing materials, products, and processes; (6) to develop suitable substitutes for existing materials, products, processes, and services; (7) to develop new materials, processes, products, and services; (8) to improve manufacturing techniques or processes; (9) to make use of by-products otherwise wasted; (10) to amass technical information leading to a better understanding of a material, process, or product; (11) to contribute to the common store of technical knowledge, with the ultimate motive of increased markets through better standards of living."

As this study points out, different companies evaluate the results of their research by different standards. It is a matter for common agreement, however, that industrial research is a necessity for the health and growth of almost any company. It is also a noteworthy corollary that "industrial research organizations which emphasize the practical applications of new theories and discoveries have been one of the greatest agencies in advancing the broad base of science."

Colleges Make Varied Charges For Industrial Research

WHILE on the subject of research it might be interesting to note a few facts about charges for industrial research at engineering colleges, revealed in proceedings(2) of a recent meeting of the Engineering College Research Association. Petroleum companies have long been sponsors of research at many colleges, largely through fellowships and grants-in-aid, but the recent war lent emphasis to the employment of college engineering experiment stations for the solution of industrial (wartime and other) problems. This trend is continuing, and, while problems are usually assigned on the basis of the available scientists and equipment at a particular school, those companies which are intent on the beginning of a new program of broad scope are giving interested attention to

(1) Voorhies, D. H., "The Coordination of Motive, Men, and Money in Industrial Research," Standard Oil Company of California, 1946. 64 pp.

(2) Anon., "Proceedings of the Annual Meeting," 1946, Engineering College Research Association (Iowa State University, Iowa City), 1946. 74 pp.

the rather widely divergent practices and charges at the different schools.

No brief summary of the facts presented at the above-mentioned meeting could do justice to the reasons behind the practices of individual schools, so no names will be mentioned here.

One school charges sponsors of projects done largely for private benefit "an amount that will compensate the University, as fully as possible, for all indirect costs;" charges sponsors of similar programs which fit into the University research objectives on a varying scale; and makes no overhead charge for research programs which are supplementary to the University's research program and thus relieve the University of the costs of sponsorship. All patents belong to the University; the most any private sponsor can obtain is a free, nonexclusive license.

A second organization (really an industrial research institute) makes a standard overhead charge of 100% of the direct salaries of the technical and scientific staff working on the project, with larger charges for research projects of a test type; "full patent protection" and "all publication rights" belong to the sponsor. Interestingly enough, a third group (a university) states that its 30% overhead charge (based on payroll expenditures) has been found to be sufficient. A fourth technical institute (college), one of the most important in this country, apparently makes overhead charges which approximate 50% of each project's "salaries and wages" items.

Private industry is currently receiving valuable research assistance from college engineering experiment stations, organizations generally established to aid in the industrial growth of their regions and in the utilization of regional raw materials. Many of these groups are now of national service as well, and their facilities and personnel are often unavailable elsewhere on a comparable basis. It is highly likely that increased industrial use will be made of organizations of this type.

Distillation Bibliography of Value to Petroleum Engineers

A RECENT publication(3) of the Engineering Experiment Station of the Virginia Polytechnic Institute is of petroleum engineering interest for two reasons (1) it constitutes a usable if not exhaustive bibliography on the important unit operation, distillation, and (2) it typifies an increasing practice among organizations of this type; namely, the publication of engineering literature searches and surveys, so that the published storehouse of technical knowledge may be rendered more readily accessible.

This particular bibliography suffers slightly from a lack of definition or a statement of limitations. A "Reference Limits" table indicates that many important primary and secondary sources were included, but, even by reference to a short subject index, it is impossible to tell (except from prior knowledge) that such subjects as azeotropic distillation are not covered completely.

Another limitation (not mentioned, but evident) is the exclusion of patents.

Despite these limitations, this will still be a usable bibliography for many petroleum engineers. Some 584 references are arranged by authors, and brief abstracts are given for each article included. The subject index includes references to the distillation of only a few substances (ethyl alcohol, natural gasoline, organic liquids, petroleum, and water), but it does relate to numerous important aspects of the unit operation itself.

(3) Villebrandt, F. C., Bryan, J. E., Couper, H. R., and Dorsey, C. L., "Distillation Bibliography." Virginia Polytechnic Institute, Engineering Experiment Station Series No. 22, 1946. 50 pp.

Government Research on Synthine Process

IN his December 31, 1946, report to Congress on the Synthetic Liquid Fuels Act, the Secretary of the Interior has confirmed recent estimates that "gasoline can be produced from natural gas for 5½ to 7 cents per gallon and from coal or oil shale for 7½ to 9½ cents per gallon." In his own words, "these figures are only a few cents higher than the present estimated cost of gasoline from petroleum. At the present rate of progress, synthetic production of petroleum products on a commercial basis is possible within the next few years."

Senator Joseph O'Mahoney (D., Wyo.) has recently introduced a bill (S. 134) to increase the cost limit of the Bureau's program from $30,000,000 to a figure of $60,000,000 and to extend the time limit of the synthetic fuels studies to a total of eight years instead of the present five (which terminate in 1949). Increased costs of materials and the fact that the "program is only now getting into full operation after nearly three years of preparation" are cited as the reasons for this measure.

It is more than interesting to note, in this connection, that "if Congress votes longer life and extra money to the synthetic liquid fuels program, as has been proposed, the Bureau of Mines intends putting increased emphasis on research into the Synthine (Fischer-Tropsch) process."(4) This would be justified according to Dr. W. C. Schroeder, chief of the Office of Synthetic Liquid Fuels, by the fact that production costs by this method "appear to have dropped so materially."

(4) Anon., NATIONAL PETROLEUM NEWS 39, No. 3, 16 (1947), "Seeks More Money and Time for Synthetics Program."

The Research and Development Division of the Bureau's synthetic fuels office, headed by Dr. H. H. Storch, has engaged in "experimental plant scale" research on "a new type of synthesis chamber which controls the (very critical) catalyst temperature by dripping a cooling oil directly over the catalyst," permitting "production rates in excess of twice (perhaps 3-5 times) those achieved in European practice." Chambers of this type may be "enlarged to any size which is practical from a construction standpoint," require much less steel than German-type units, and (according to the Bureau) "show promise of equalling in industrial applicability the fluidized catalyst process;" the latter, of course, will shortly be used in at least two commercial plants.

Laboratory-scale experiments in 1946 included work on a liquid-phase catalyst suspension process, a hot-gas recycle process, and fluidized fixed bed processes designed to produce larger-than-normal Diesel oil fractions.

In addition to its work in Alabama on underground gasification of coal, the Bureau's Synthesis Gas Production Division, following a critical investigation of foreign and domestic gas-making methods, has decided "to concentrate on the development of pulverized fuel gasification in internally heated reaction chambers similar to the Wintershall-Schmalfeldt process used successfully in Germany." Work is also in progress on "the production and storage of (low cost) oxygen."

There is little question that the Bureau's work constitutes one of the largest present research programs in the field of synthetic liquid fuels. It is highly significant to note, however, that Robert R. Russell of the Standard Oil Development Co. recently stated that one-third of his company's present annual research budget is devoted to studies in this field. Moreover, many other petroleum companies (Texas, Gulf, Standard of Indiana, Phillips, etc.) and others (Koppers, Kellogg, Pittsburgh Consolidation Coal, etc.) are also busily engaged in research on the Synthine and other liquid fuel processes.

Government programs calling for large-scale expenditures for research must run the gauntlet of congressional scrutiny and, if truly worthwhile, must serve a very broad purpose. Much of the "propaganda" connected with the passage of the initial Synthetic Fuels Act—the wartime need for the program, the necessity for "demonstration" plants, and the imminence of a petroleum shortage—was and is open to question, but there is little doubt that the program will yield important data, especially if extended at least in time. Proper cooperation with industry and avoidance of unnecessary duplicatory work could make this synthetic liquid fuels program an outstanding example of Governmental research in applied fields of science.

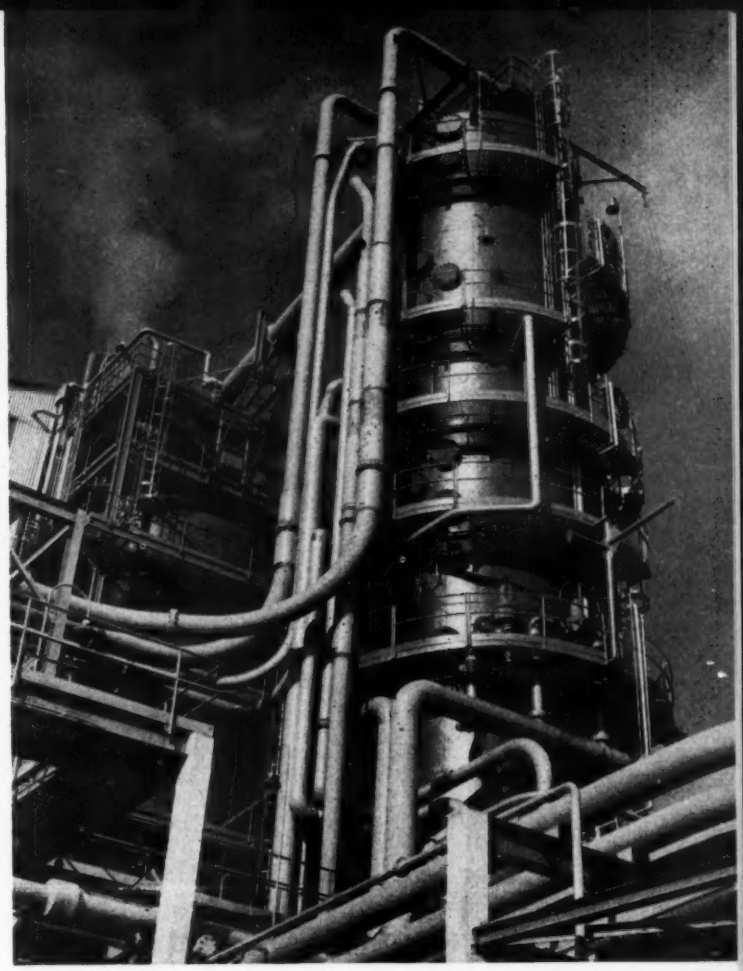
CATALYTIC CRACKING

Fluid 'Cat Cracker' Designed to Use New MS Catalyst

By D. P. THORNTON, Jr.

Assistant Editor
PETROLEUM PROCESSING

Improvements and materials savings in a new Fluid unit were achieved through designing especially for using microspherical catalyst, and through other new engineering features. Inclusion of a feed preheater, making possible lower rate of circulation of catalyst, also contributed to design economies. The furnace will also superheat wet steam generated in cooling the catalyst and slurry streams.



Fractionator of Shell's new Fluid cracking unit at Houston is 17-ft. 6-in. internal diameter by 89 ft. high. Bottom half is lined with stainless steel. "Hot" lines are insulated to protect workmen. Each walkway has fire protection facilities

THE principal design features of the new Fluid catalytic cracking unit and allied facilities at the Houston refinery of Shell Oil Co. stem from the intended use of microspherical synthetic catalyst. Basic elements of the process and operating techniques follow closely accepted practice with Fluid plants. The unit includes a feed preheater which combines preheating the charge with superheating wet steam generated in cooling the catalyst and slurry streams.

The new Fluid unit is the first designed to operate on microspherical catalyst. This synthetic material, which flows far more freely than the usual ground catalyst, has made possible a marked reduction in the height of the unit, which is only 160 ft. to the top of the stack. Top of the regenerator cone is but 140 ft. above grade and the reactor 110 ft. This reduction in height is in part permitted by the use of the new catalyst, but mainly by designing for equal pressure operation with low drop in pressure across the slide valves.

Permits Lower Circulation Rates

The main advantage of the feed preheater is to permit lower circulation rates for the catalyst, but it also has the advantage of permitting more flexible operation of the unit. By reducing catalyst circulation rate to that necessary for the desired conversion and to maintain reactor bed temperature at the selected value, smaller diameter risers and stand pipes are permissible and erosion rate is reduced. Lower catalyst circulation rate also makes possible a much higher steam stripping efficiency than with earlier units, reduces amount of steam required, cuts down quantity of regeneration air and permits other savings.

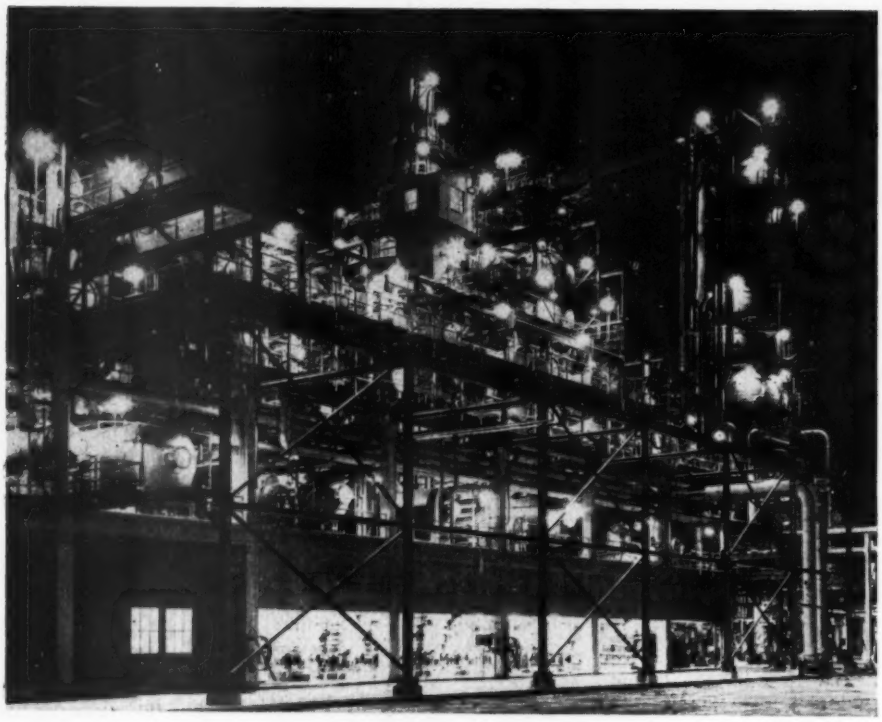
The new catalyst, which has a lower attrition rate than the ground synthetic, also eliminates need for electrostatic precipitators, which are not only expensive to install but require considerable maintenance and frequently are an operating "headache" on such large units.

A new design of grid-plate is used in both reactor and regenerator. In place of the earlier solid metal grid, hollow grid beams are used, around which are wrapped replaceable "wear plates" to take erosion. The beams are molybdenum steel in the reactor, where temperatures will not exceed 950° F., and chrome-molybdenum alloy steel in the regenerator. The hollow design gives strength and reduces weight. In operation it has shown good distribution of catalyst and vapor.

Oil vapor or air is disengaged from the catalyst by two series stages of Buell-designed cyclone separators. Each stage in the regenerator contains 6 separators in parallel. Five in parallel per stage are required in the reactor. Oil stripping from catalyst in the reactor requires only 10,000 lbs. per hour of 550° F., 225 psig., superheated steam when catalyst is circulated at the 13 tons per minute rate necessary in this unit. This is less than half that required in the older units, where catalyst rates were upward of 30 tons per minute. The stripping section in this reactor looks like an egg-crate. It has 26 box-sections, each 23 in. square and 15 ft. high.

Control of regenerator bed temperature is maintained by two catalyst coolers, through which regenerated catalyst is continuously circulated. These units are of water-tube type, contain 1220 tubes, 1.5-in. O. D., and weigh 84 tons. Each produces 80,000 lbs. per hour of saturated steam at 225 psig., most of which is superheated for use at the unit and augments basic refinery steam supply. Another 40,000 lbs. per hour is generated in cooling 4 oil slurry streams from the fractionator column to control tower bottom temperature, bringing total steam produced to 200,000 lbs. per hour.

Reactor pressure is controlled by compressor suction, pulling on the fractionator overhead condensate accumulator. Suction pressure on this drum is so adjusted that it will compensate for pressure drop across the Fluid unit vapor transfer line, fractionator, overhead vapor condensor and the accumulator, and maintain 8 psi in the reactor. A pressure



Night view of 3-story pumphouse. All product coolers, exchangers and condensers are on top deck, with overhead chain hoist permanently installed (left); second deck carries all dry drums, receivers and accumulators while all pumps and air blowers are on ground floor, also served by overhead hoists

controller on the accumulator sets governor speed on the compressor drive.

Regenerator pressure is more easily controlled. The stack is equipped with a manually adjustable square orifice which permits a rough adjustment of back-pressure on the vessel. A 16-in. by-pass line tied into the stack just ahead of the orifice and equipped with a motor operated butterfly throttling valve gives the final, precise adjustment. Manual adjustment of the stack orifice during start-up is the only operation for this control which cannot be made from the control-room panel.

The fractionator on this unit is the largest in diameter ever installed in a Shell plant for catalytic cracking, 17 ft. 6 in. I. D. by 89 ft. high. Overhead is wet gas; "wild gasoline" and gas oils are taken in two side-streams, and heavy gas oil as bottoms. The two side streams flow through strippers of identical design before returning to the basic refinery for further processing; the strippers are 4 ft. I. D. by 16 ft. high.

No special protection against sulfur corrosion was considered necessary in the design of the unit, although it will charge vacuum-flashed distillate from West Texas sour crude. The entire unit is carbon steel with the exception of the fractionator column, which is stainless steel lined in the bottom half, and the heavy gas oil stripper, which is lined with 18-8 stainless steel throughout.

The pumphouse is unique in that it has three stories. The top deck carries all product coolers, exchangers and condensers and is open to the sky. Dry drums, receivers and accumulators occupy the commodious second deck. The ground floor is given over to all necessary pumps and, in addition, two 2400-h. p. turbo air-blowers (26,400 cu. ft. per min. at 17-18 psi.) An overhead trolley system is installed on all levels to handle equipment for maintenance or repair. The traveling chain hoists are capable of lifting any item of equipment in the building if necessary.

The sky-lighted compressor-house contains seven 800-hp Ingersoll-Rand gas-engine compressors delivering gas at 325 psi., arranged in two rows. One is a standby and space has been left for an eighth unit. At the front of the room are two small air compressors (one a standby) which supply 50 psi. air for instrumentation, instrument bleeds and to aerate the catalyst standpipe. All instrument and instrument-bleed air passes through a silica-gel drier.

All compressor piping is above ground and outside the building except where lines lead to the compressors. Headers divide at the front of the building into a U-shape. Three overhead travelling hoists have been provided, for pulling heads and cylinders. The operator's station is an enclosure at the front of the building, which otherwise is open on three sides to reduce the noise level and more particularly for ventilation should there be leakage of gas.

Charge Preheater

During the war very few, if any, of the catalytic cracking units built had any furnace provisions for preheating the charge stock. They depended upon residual heat in the regenerated catalyst to supply preheat and vaporize the charge. In the new Shell installation, however, the charge is already heated to almost complete vaporization at the time it mixes with the catalyst.

Because of this lack of dependency upon the residual catalyst heat for preheating, the rate of charge does not automatically prescribe either rate of catalyst circulation or catalyst temperature. By thus being able to reduce catalyst circulation rate to that necessary for desired conversion and to maintain

TABLE 1—Present Operating and Design Data, Fluid Cracking Unit, Shell Houston Refinery

Throughput, b/d:	
Fresh feed	18,000
Slurry recycle (Max 0.5% catalyst, 0.02% actual)	1,200
Total throughput	19,200
Catalyst:	
Catalyst: oil ratio (raw feed)	7:1
Circulation rate, tons/min.	13
Unit capacity, tons	600
Coke on catalyst, %C.:	
Spent catalyst	1.5
Regenerated catalyst	0.4-0.5
Regenerator carbon burning capacity (design), lbs/hr.	19,200
Operating conditions:	
Reactor bed temp., ° F.	900-905
Regenerator bed temp., ° F.	1040-1050
Reactor pressure, psi	8
Regenerator pressure, psi	8.5
Conversion, % on raw feed	58
Feed and Products:	
Gas Oil Charge (W. Tex. sour)	
Gravity, ° API	27-28
IBP, ° F.	440
50% point, ° F.	660
End point, ° F.	900
Hydrocarbon products, b/d:	
Debutanized motor gasoline, 400 E.P.	5,000
Light gas oil	4,255
Heavy gas oil	2,960
C_2 and lighter (1000 cu. ft./day)	8,000
C_3's	2,000
C_4's	3,200
C_5's	1,600
Steam, lbs./hr.:	
Generation	
Catalyst coolers (2)	160,000
Slurry coolers (4)	40,000
Total, 225 psig. wet steam	200,000
Superheated steam 55 at 0° F., 200 psig.; total	165,000
Steam Distribution:	
FCC for stripping, superheated	10,000
FCC for utilities, superheated	95,000
Basic refinery, superheated	60,000
Gas concentration unit, wet steam	35,000

reactor bed temperature at the selected value, it was possible to design the unit with smaller diameter risers and stand pipes.

Lower catalyst circulation rate also makes possible a much higher steam stripping efficiency than with earlier units, reduces amount of steam required, cuts down quantity of regeneration air, and reduces rate of erosion.

An unusual feature in the design of the furnace is the inclusion of steam superheating facilities along with the charge preheater duty. Steam superheating facilities were included for two reasons:

1—More superheated steam would be needed at the unit than existing refinery facilities could supply. It was a question of building another furnace at the boiler plant to take over the load or providing means for getting the additional steam at the unit itself.

2—There would be considerable waste heat at the Fluid unit which could be conserved by installing wet steam waste-heat boilers. Having this wet steam handy made it a relatively inexpensive proposition to superheat it to the desired degree and use it there, pumping the excess into the refinery superheat steam main.

The furnace is the latest Foster-Wheeler design, gas floor-fired type. Three of its four cells heat the charge to 820-825° F., while the fourth superheats 165,000 lbs. per hour of wet steam at 225 psig.

Ultra-Modern Control Room

The main unit control house in appearance would credit the lobby of a modern office building. Walls are tiled in light green, floor is terrazzo, instrument cases and panels are in pleasing shades of pastel green and ceiling is a white, sound-absorbing composition. Lighting is all indirect. Two large chart tables go down the center of the room. In the back of the air-conditioned, sound proof building are toilet facilities, a small control laboratory, engine room and the supervisor's office.

The control panel runs the length of the building from floor to ceiling, split in the center by a hallway. The panel is subdivided into 20 sections, each numbered. Beside each bank of instruments are small permanently mounted flow-charts which show where each instrument in a particular bank is connected on the unit and what it does.

In general appearance and detail, the entire Fluid unit installation shows careful planning for operator comfort, ease of operation and simplified maintenance. The only underground piping is in sewers; everything else is overhead on racks and readily accessible. In the control room, there is a minimum of 6 ft. behind the control panel for maintenance access to instruments and wiring. In the pump-house there is generous spacing of equipment and no reason to tear out one item in order to get at another. There is a solid floor under all exchangers, coolers, drums, accumulators and so on, and room enough around them for men to work. In the compressor house there is sufficient space between all units to perform any necessary work.

On the "cracker" itself the same provisions for maintenance are evident. Most of the equipment is on the ground or close to it. Remote-operated valves are everywhere. Rails and traveling chain-hoists are built in over the slide-valves, for example, and a large freight elevator goes up to the 15th floor of the unit to carry heavy items when repairs are in progress. Stairways and the elevator allow easy but seldom necessary operator-access to all parts of the unit. There are two catalyst storage hoppers. One, of 700 tons capacity, will easily contain the entire charge in the unit; the other, 275 tons, holds catalyst make-up. A vacuum-lift is installed to quickly unload catalyst from cars on the railroad spur. Catalyst is blown over to the cracker by air pressure.

Operators for the new Fluid unit had to be trained from scratch. Supervisors and refinery technologists, together with contractor's personnel, wrote a complete instrumentation and operating manual. Every possible contingency which could be foreseen was covered in detail. Selected stillmen and operators were sent to Shell's Wood River plant for actual experience on the unit there, receiving respectively 12 and 6 weeks training.

Upon their return to Houston, regular classes were organized which used the manuals for textbooks. The men worked part time in the classroom and spent the balance on the unit during its construction. Every attempt was made to give the men data on the instruments, their purpose, and where and how controls were tied in. In operations, details of design were covered, theory of the process, emergency operation and other details.

TABLE 2—Characteristics of Type MS-A Microspherical Catalyst*

Analysis, Wt.—%	
Alumina (as Al_2O_3)	10.5
Silica (by diff.)	89.5
Iron	0.045
Sodium (as Na_2O)	0.006
	100.051

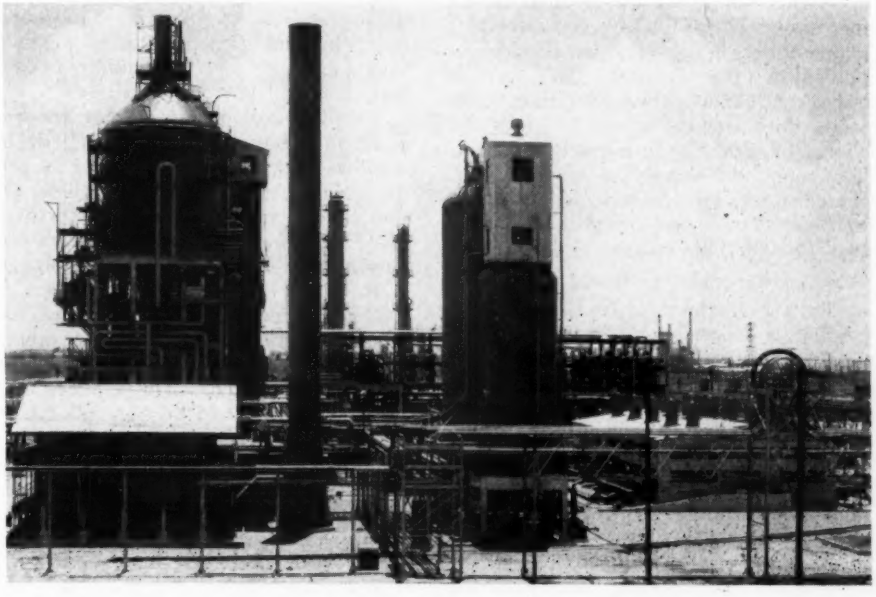
Particle size distribution	Type MS-A	Ground
% through 40 mesh	100	100
% through 100 mesh	95	94
% through 200 mesh	56	56
% less than 40 microns	17	33
% less than 20 microns	2.5	15
% less than 10 microns	0.5	6
Average particle size, microns	67	65

* From American Cyanamid Co. bulletin.

Trial Operation

At present the unit is charging approximately 18,000 b/d of vacuum flashed distillate from sour West Texas crude. Designed for 17,500 b/d capacity in the war-time aviation gasoline program, it has not been "opened up" to full-speed, hence operators do not know its ultimate capacity but believe the figure will be between 25,000 and 30,000 b/d.

The microspherical catalyst for which the Fluid unit was designed has just become commercially available. For starting up on Sept. 21, used synthetic catalyst was charged. No operating difficulties had occurred when this was written. Only complaint had come from



Shell Oil Co.'s new Fluid catalytic cracking plant at its Houston refinery. Left is furnace which preheats feed and superheats wet steam; left background is Fluid "cracker", middle foreground, catalyst storage; right, compressor house

Cyclone separators for removing catalyst from vapors, being installed in reactor of the Houston Fluid catalytic cracking unit

plant office workers, objecting to the noise during operations. A muffler will go on the stack during the shutdown for inspection. After the inspection, the new MS catalyst will be charged and trial runs begun to establish ultimate and optimum throughput rates.

Table 1 contains a brief summary of present operating conditions and product yields, which are not unusual except for catalyst oil ratio and regenerator bed temperature. Table 2 gives characteristics of the new catalyst. Hot feed is charged direct from vacuum flash units to the feed preheater, which brings the charge to 820° F. In event the vacuum flash units are supplying an excess of charge stock, the overage is cooled in condenser boxes and diverted to one of two 140,000 bbl. storage tanks nearby.

Synthetic crude produced, as stated earlier, is fractionated to unstabilized gasoline and two grades of gas oil. An oil-slurry stream of approximately 1000 to 1200 b/d is recycled to the unit. At first an operating maximum of 0.5 lbs. catalyst per gal. of oil was set up for this stream, but so efficiently have the cyclone separators removed this material that catalyst content has averaged consistently around 0.02 lbs. per gal.

No protection has been considered necessary against sulfur corrosion, although the feed is quite sour. The entire unit is carbon steel with the exception of the fractionator column, which is stainless steel-lined in the bottom half, and the heavy gas oil stripper, lined with 18-8 stainless throughout.

Gas Plant Has New Features

The gas concentration unit is not properly an integral part of the Fluid unit but is an auxiliary. It processes two streams from the Fluid unit; overhead wet gas, non-condensible there, and the gasoline fraction. It discharges five streams, ethane and lighter, propane and propylene, butanes and butylenes, pentanes and pentenes, and depentanized gasoline.

Gasoline is depentanized for convenience in treating operations. Both incoming streams are charged to a conventional rectified absorber, where C_2's and lighter are taken overhead to plant fuel while bottoms are successively depentanized, depropanized and debutanized.

Depentanizer bottoms are motor fuel stock and transferred to other process units. The ethane and lighter cut, fuel gas, is not treated. The C_3 stream is contacted with tripotassium phosphate; C_4 and C_5 streams are separately washed with caustic. The C_3 and C_4 streams are charged to other portions of the plant for further processing, and the C_5 stream goes to gasoline blending for reincorporation into gasoline.

The same general features distinguish the gas plant from ordinary construction as were noted in the Fluid unit, and the control house is a smaller counterpart of its larger sister. All tubular equipment such as reflux accumulators, surge drums, and so on is on the ground, particularly for easy maintenance access and also to reduce structural steel support otherwise required. In this connection, no operating difficulties have been experienced from pressure surges by having accumulators above the condensers, although undoubtedly there are some run-backs of liquid.

Each item of equipment is well separated from its neighbor for easy access and yet the plant is compact. Pumps, for example, are separated 20% more from each other than is customary in any previous Shell construction. This permits logical manifolding and instrumentation.

All piping arrangements have been built to an operating experience standard, particularly on columns, accumulators, reboilers and pumps. All is above-grade except for sewage. These recently-developed piping standards will be used in all future Shell plants, instead of permitting each contractor and equipment designer to use his own ideas. They are particularly intended for operating and maintenance simplicity, embody good engineering practice and especially stress safety. For example, there are no screwed couplings into vessel shells or connections and all pressure gauge taps, instrument taps and sample lines are outside the block valves on the unit. Shell is said to be considering adopting a standardized design of flange connection for thermowells and sample connections on fractionator columns, although the present unit is conventionally equipped in this respect.

Adequate fire-protection and drop-out facilities are provided throughout. The plant is completely equipped with hydraulically-actuated drop-out valves on all fractionator columns and treaters. Water-fog nozzles are installed in all pump rooms, and all uninsulated vessels are equipped with water sprays. Operating personnel point out that drop-out facilities pay off on maintenance as well as safety. A vessel so equipped can be drained and steamed, ready for entry, in less than half the time ordinarily required.

Size of the new plant installations is revealed in a few statistics for Shell's Houston refinery, which indicate the cooling water system has a pumping capacity large enough to supply a city of 150,000 people. Electrical requirements approximate those of a town of 25,000. The new units occupy 75 acres.

Major contractors for the new installations were Foster-Wheeler Corp., New York, on the Fluid unit; C. F. Braun & Co., Alhambra, Cal., on the gas plant, and the Fluor Corp., Ltd., Kansas City, Mo., on the feed preparation units and auxiliaries. Since the unit was built on virgin property, it was necessary to provide all facilities, such as drainage, sewers, roads, power lines, water supply, and railways, before construction could start.

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PLANT PRACTICES

Practical Tips and Ideas for Improving Refinery Operations

Tower Lining Method Reduces Rivet Head Corrosion and Cuts Welding Requirements

AN ingenious method of affording more corrosion protection for rivet-heads in vessels lined with stainless steel strips and eliminating necessity of welding around each individual rivet-head has been developed by J. R. Glayzer, of the Kansas City refinery of Phillips Petroleum Co. The method of protection is told graphically by the accompanying photographs, submitted with the idea in the company's employe-suggestion award program.

Fig. 1 shows a portion of a stainless steel plate lining in a bubble tower at the riveted section. The lining at the riveted seam section consists of stainless steel strips with holes cut in them at the proper intervals to accommodate the rivet heads in the seam. Caps then are welded over each rivet head to protect it from the corrosive condition.

This method formerly used at Kansas City, in addition to requiring welding a cap over each rivet after the strip was in place, necessitated bringing caps into the vessel separately from the strip and buying or making them prior to installation. Fig. 2 shows a strip with holes cut in it prior to use, with some of the caps ready for installation.

Fig. 3 illustrates Mr. Glayzer's simple suggestion. He advocated preforming the strip with semi-ellipsoidal indentations stamped in them of the necessary size and at the proper intervals to cover the rivet heads in the vessel.

For installation the formed plate strip is treated as though it were for an unriveted portion of the vessel. That is, it is welded at the edges only, saving the time required for tacking the perforated strip down around each rivet head and subsequently welding on the cap. The suggestion has resulted in decreased down-time for vessels during lining and reduced lining cost.

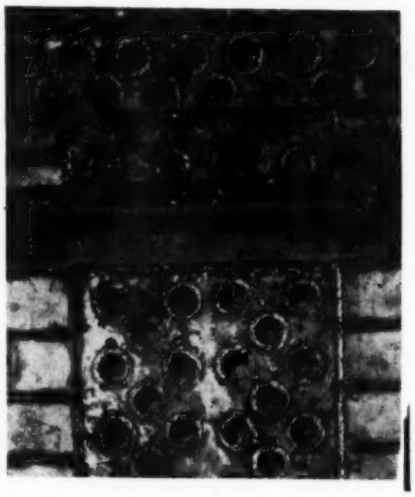

Fig. 1 (Above)—Portion of riveted seam area of a vessel lined with stainless steel strips, using former method at Phillips' Kansas City refinery

Fig. 2 (Left)—Prepared strip lining for riveted area. Holes correspond to rivet heads. Caps then are welded over

Fig. 3 (Right)—Formed strip containing semi-ellipsoidal indentations can be installed by seal-welding at edges only, eliminating costly welding around individual rivet heads. The plate shown was actually too hard for the die-forming operation and cracked while in the press. It was salvaged, however, by seal-welding cracks after installation

Simple Extension on Weld Shield Stops Arc Glare from High Jobs

SOMETIMES when a welder works on trucks or equipment in enclosed areas, his job takes him so high that the usual welding shield is inadequate to protect his fellow-workers from the glare of the arc.

Two garage employes in one plant suggested a simple extension on top of the ordinary shield. Constructed of a pipe framework and covered with canvas, the extension is hinged to the main shield. When off-the-floor work is in progress, it is raised. When not needed, it is out of the way.

As used in this plant, the extension shields make a structure about eight feet high, but may be fabricated in any dimensions desired.

Mercury Seal Facilitates Measurement of Molten Salt Flow in Catalytic Crackers

By ALFRED KRIEG, Supervisor, Instrument Department
Socony-Vacuum Oil Co., Inc., Paulsboro (N. J.) Refinery

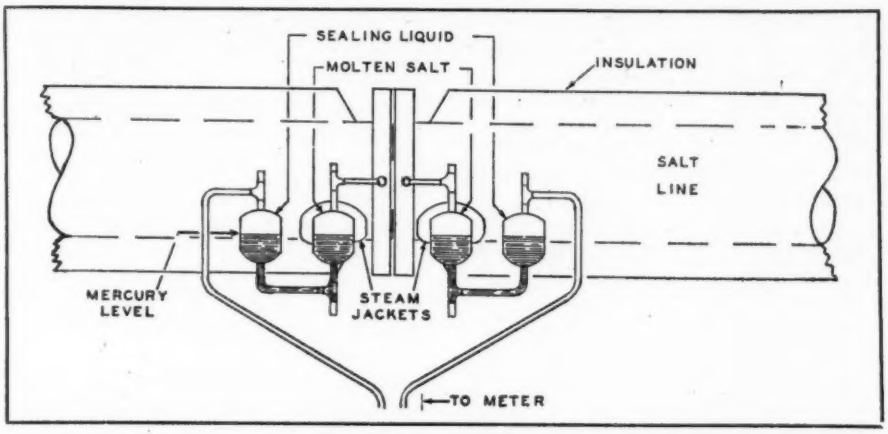

Fig. 4—Sketch showing installation of a pair of mercury seal pots on each side of orifice for measuring flow of molten salt in a catalytic cracking unit

UPON the completion of a newly designed catalytic cracking unit at the Paulsboro refinery of Socony-Vacuum Oil Co., Inc., the Instrument Department was confronted with the problem of measuring the flow of molten salt, or lavite, from the cracking cases to the heat exchangers. The lavite is used as a heat transfer medium, keeping the process at a predetermined operating temperature by absorbing the heat released when the catalyst is regenerated and utilizing it in a pre-heater and a steam generator.

Because the lavite has a specific gravity of 1.76 at a flowing temperature of 825° F. and solidifies at 300° F., the problem involved sealing it from the meter body, yet maintaining it in a molten state so that its flow could be measured.

The final arrangement developed is shown in Fig. 4. It consists essentially of two large diameter seal pots for each orifice tap, connected as indicated. The seal pots are each filled to the half way mark with mercury.

The two inner pots are filled above the mercury with lavite. In order to keep the lavite in a molten state, these pots and the connecting lines to the orifice are steam-jacketed and insulated. The two outer pots and the piping to the manometer are filled with a light oil sealing solution. The temperature in these pots is relatively low so that a minimum amount of vaporization will take place in the light oil.

Thermocouples are installed in the pots containing the molten salt to indicate the temperature and to assure a molten state.

In operation a differential produced by the orifice is transmitted through the mercury seal pots to the manometer. Since the diameter of the pots is relatively large as compared to that of the mercury chamber in the manometer, the differential in the mercury level in the pots is slight for full-scale pen deflection.

The accuracy of the meter was determined by making a water column check at the pots, the column being connected to the inner pot and the meter checked using standard procedure. The accuracy of the installation proved to be within suitable limits.

The large volume of mercury used in the seal pots tends to reduce the meter sensitivity somewhat; however, for the average application, this factor does not affect the accuracy of the measurement.

If, for any reason, a leak in the seal occurs, serious plugging of the lines will result; therefore, special care must be taken in the installation to insure tight, leak-proof joints.

A number of inquiries have been received by the Plant Practices Editor concerning an in-line pump mentioned in an item in this section in the January, 1947, issue of PETROLEUM PROCESSING. The pump was designed as part of a piping arrangement for a truck loading station at Republic Oil Refining Co.'s Texas City refinery.

Readers who wish further information about the pump should direct their requests to the A. O. Smith Corp., Milwaukee.

Save 28 Man-hours Dismantling Time by Improved Method for Cleaning Exchangers

A TOTAL of 28 man-hours of labor in acid-cleaning heat exchangers on the Fluid catalytic cracking units at one large refinery were saved by installing wash-out connections, thus avoiding an unnecessary dismantling operation.

Generally, two or more exchangers in a battery will be piped together as shown in Fig. 5, a check valve on one side of the pair and a spool on the other. In such an arrangement, it is necessary to unflange and remove both the check valve and the spool in order to make connections for acid-cleaning the exchangers.

If the arrangement is like the one shown in Fig. 5, the elbow ahead of the check valve must also be removed to facilitate cleaning. A pair of 8 x 2-in. reducers are then installed for the acid connections.

In the labor-saving method, the piping connections were modified as indicated. A 2-in. connection, normally plugged, was provided in the spool and another in the top of the check valve.

When it is desired to clean the exchangers, they are purged and washed in the usual manner, then acid lines are connected to the two points shown.

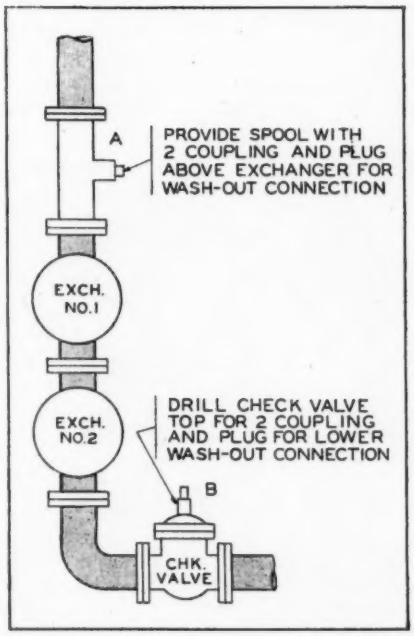
A
PROVIDE SPOOL WITH 2 COUPLING AND PLUG ABOVE EXCHANGER FOR WASH-OUT CONNECTION
EXCH. NO.1
EXCH. NO.2
DRILL CHECK VALVE TOP FOR 2 COUPLING AND PLUG FOR LOWER WASH-OUT CONNECTION
B
CHK. VALVE

Fig. 5—Modified piping arrangement on cat cracker heat exchangers. Acid line is connected at A and B, normally plugged during operating period

Utopia Refinery Pipefitters Never Injured on the Job

By FRANK J. SLUZE, Safety Director
Ashland Oil & Refining Co.

Standard practices of the pipefitting department personnel in the mythical refinery continue to demonstrate that an accident-free plant is not such a fairy-tale after all, but definitely a strong possibility

THIS month's inspection at Utopia refinery is in the pipefitting department, so let's first take a look at the pipe shop itself. Notice the good housekeeping—oil-and-grease absorbent has been sprinkled around the machines to sop up the oil drippings.

Control buttons are conventiently located, making it easy to shut off power in case of an emergency. The buttons also are in recessed openings, preventing accidental bumping and starting the machines unintentionally. We also observe that the threading and cutting machines have been placed so as to keep exits and aisles clear of pipe projecting from the machines. Illumination is sufficient to give almost daylight visibility over the work.

Now let's "mosey" out into the operating area. Two pipefitters are working on some overhead piping—notice that they are using a substantial scaffold. Scaffold supports are at least 4 by 4-in. lumber. Floor planks are 2-in. lumber, free from knots, checks, and cracks. The flooring is nailed down securely—no chance for any plank to slide or tip.

A 4-in. high toe board has been provided to prevent loose objects such as hand tools or fittings from being accidentally kicked off. The top railing is standard, 42-in. high, and an intermediate rail has been provided. Supporting uprights have been bolted or nailed in place. We learn that the foreman in charge of the job has examined the scaffold and declared it safe both as to material and workmanship.

Utopians avoid such oil shower baths by opening bottom bolts on flange couplings first. They also use an empty drum to catch dripping oil

The workmen are attempting to insert a blind in a line. They aren't using wedges to spread the flange—such a method could create sparks. Instead they are using flange jacks.

Notice that in loosening the flange bolts they open the bottom ones more than the top as a precaution against internal pressure causing a splash. By this procedure, they not only direct any possible splash toward the ground but also use the line itself as a shield against upward splashing.

For possible spills underneath, they have placed several empty drums to catch the flow of oil from within the line. Also notice the "Danger, Men Working Above" signs at both entrances to the job—a warning to persons traveling in this vicinity.

Moving on, we find fitters putting in a new valve. These men are taking the precaution to blow out chips and dirt from the line. Such debris would damage the valve seat.

Next we come across a fitter who is painting the threads of a pipe which is to be connected to a valve, and we see that he is painting the pipe threads, not the valve threads. A good idea—paint on the valve threads would only collect grit and scale which would later lodge on the valve seat, eventually causing valve failure.

We have now arrived at a rigging job. The men are replacing a length of 12-in. pipe up near the top of a tower. The length has been removed from the line and will be lowered to the ground; then the new length will be hoisted in its place.

An inspection of the air hoist shows the throttle working safely, the clutch in good operating condition, and the brake capable of holding the drum in place with the anticipated load. Inspecting the rope, we find no broken strands or twists or kinks, and the sling is securely fastened with clamps.

One man is directing the work. He is the only one giving the hoist operator signals. Warning signs have been placed at all approaches to the job to prevent anyone from walking under the suspended load.

Over there a pair of pipefitters are pulling a tube bundle out of a shell. Note that the "puller jack" is firmly secured. The hook is locked with a cross clamp to prevent it from straightening out or slipping off. Both men are in the clear should something let loose and fly. In case of undue resistance, one of the men will investigate the cause and free the bundle. After the bundle is partly out a vertical sling is attached to keep it from falling.

They All Wear Clean Clothing

We can't help noticing that all fitters are wearing clean clothing—free of grease, oil, or other contamination—a good safety precaution. It prevents accidental ignition of clothing and skin irritations.

In our contacts with the several crews, we couldn't help seeing how all material being replaced was put on salvage benches where it was to be sorted out—salvageable material to the salvage shop and unsalvageable material to the junk heap. Such benches have two distinct advantages—the pick-up man can collect the material easier and the housekeeping is improved, eliminating bad tripping hazards which would exist if the material were left on the floor.

A spot check of hand tools shows no dinges to indicate that wrenches are being used for hammers, no strained jaws, and no broken handles. The jaw "teeth" are not flattened and are therefore capable of getting a good "bite." Hammers have smooth, proper length handles which are securely wedged to prevent the head from flying off. Chain hoists are well oiled and clean, as are also the "puller jacks" and pipe tongs.

Next month we will take a look at the electrical department, so be with us, won't you?

In Utopia Refinery, only ONE man directs hoisting operations. It's less confusing to the hoist operator

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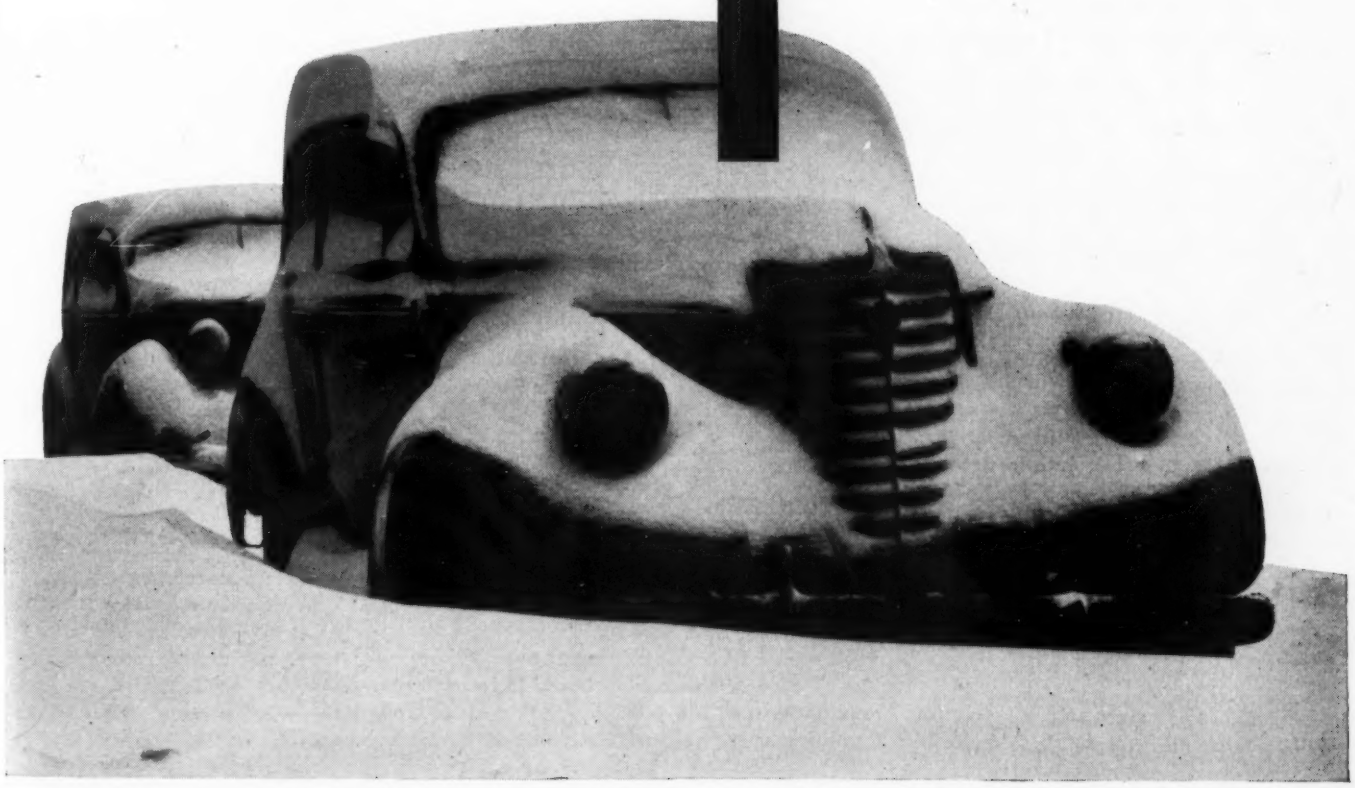


Patent Trends in Petroleum Refining

By Peter J. Gaylor

Patent Attorney and Editor "The Technical Survey"

Developments disclosed in the patents reviewed below include:

Naphtha sweetening improved by controlling air regeneration of caustic.

Selective absorbents for hydrocarbons made by hydrothermal methods.

Standard Development's new weed killer said to be permanent cure.

Caustic Sweetening of Naphthas

IN the sweetening of petroleum distillates with caustic, the usual procedure is to employ a "solutizer" such as naphthenic acids, isobutyric acid, cresols, amines, etc. for increasing the solubility of the higher mercaptans in the caustic. Also, there is generally employed an oxidation catalyst such as tannin, polyphenols, or phenolic hydroxy compounds, in the regeneration step to aid the oxidation of the mercaptans to disulfides.

If the oxidation of mercaptans is carried out to complete destruction of the latter, there is danger of also inactivating some of the catalyst by intensive oxidation. In its U. S. 2,413,945, Standard Oil Co. (Indiana) controls the air regeneration of the caustic solution so that the regenerated caustic retains a small but essential amount of mercaptans sufficient to prevent destruction of the regeneration catalyst. The gasoline is extracted to a low mercaptan content (less than 10 mg. mercaptan sulfur per 100 ml.) with the regenerated caustic solution. Sufficient air is then introduced in the presence of the gasoline and regenerated caustic to oxidize the remaining mercaptans in the gasoline, at the point of introduction, to render the gasoline sweet or substantially sweet to the doctor test.

In carrying out the process in this manner, the higher mercaptans which are most difficult to extract and yet most readily oxidized are converted to disulfides in the presence of the regenerated solution without materially reducing the mercaptan content. The caustic is then employed in the usual way to extract the gasoline, after which it is recycled to the regeneration step.

The process may be more readily understood by referenee to Fig. 1 showing the flowsheet involved. Sour distillate is fed through line 10, and into pretreater 13 which removes the hydrogen sulfide and part of the phenols, after which it is fed into the bottom of extracting tower 11 counter current to a stream of caustic containing 5-30% solutizer agent and 0.1-2% oxidation catalyst. As the gasoline flows up through tower 11, the mercaptans are selectively dissolved by the caustic, preferably at as low a temperature as possible.

The caustic solution is withdrawn through line 18, heated at 19 and pumped into regenerator 20 maintained at 100-500 psi and about 130° F. Air is injected at 21 and leaves through vent 22. The amount of air is controlled to prevent excessive oxidation and resulting degradation of the tannin catalyst. This caustic is then allowed to settle in section 24 from which the oily disulfide layer (formed by oxidation of mercaptans) is withdrawn. The partially regenerated caustic should contain 100-400 mgs/100 ml. of residual mercaptan sulfur. If the mercaptan sulfur is reduced to an amount appreciably lower than this, then a substantial loss in regeneration catalyst will take place. If the amount is above 400 mgs/100 ml., the subsequent sweetening operation will not be satisfactory and an excessive amount of disulfide may be introduced into the gasoline.

From separator 24, the regenerated caustic solution goes by line 12 and cooler 12a back into the top section of mercaptan extractor 11 wherein a stream of air is introduced through line 26 just sufficient to convert the mercaptans remaining in the gasoline to disulfides without appreciably lowering the mercaptan content of the caustic.

The presence of the gasoline serves to speed the reaction between air and mercaptans dissolved in the caustic-solutizer, possibly shifting the equilibrium in the direction of disulfide formation and also perhaps by its action in supplying dissolved oxygen to the caustic solution. There are indications that the oxidation reaction proceeds largely in the oil phase.

By means of this process, the heavy mercaptans are selectively oxidized and removed in the regenerator so that the caustic solution returned to the gasoline treater contains mainly mercaptans of low molecular weight which are resistant to oxidation, but which are preferentially soluble in the caustic. Hence, they are

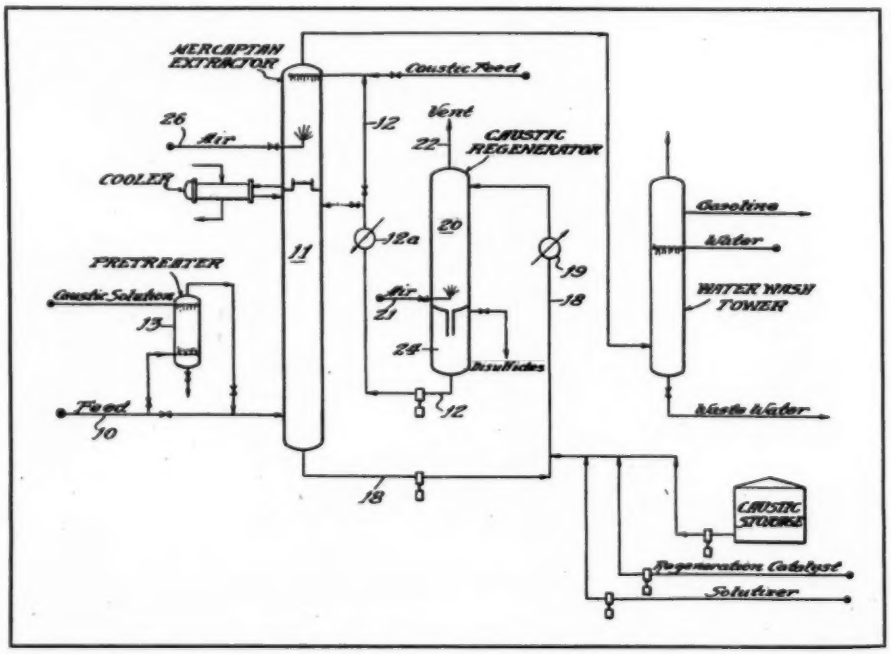
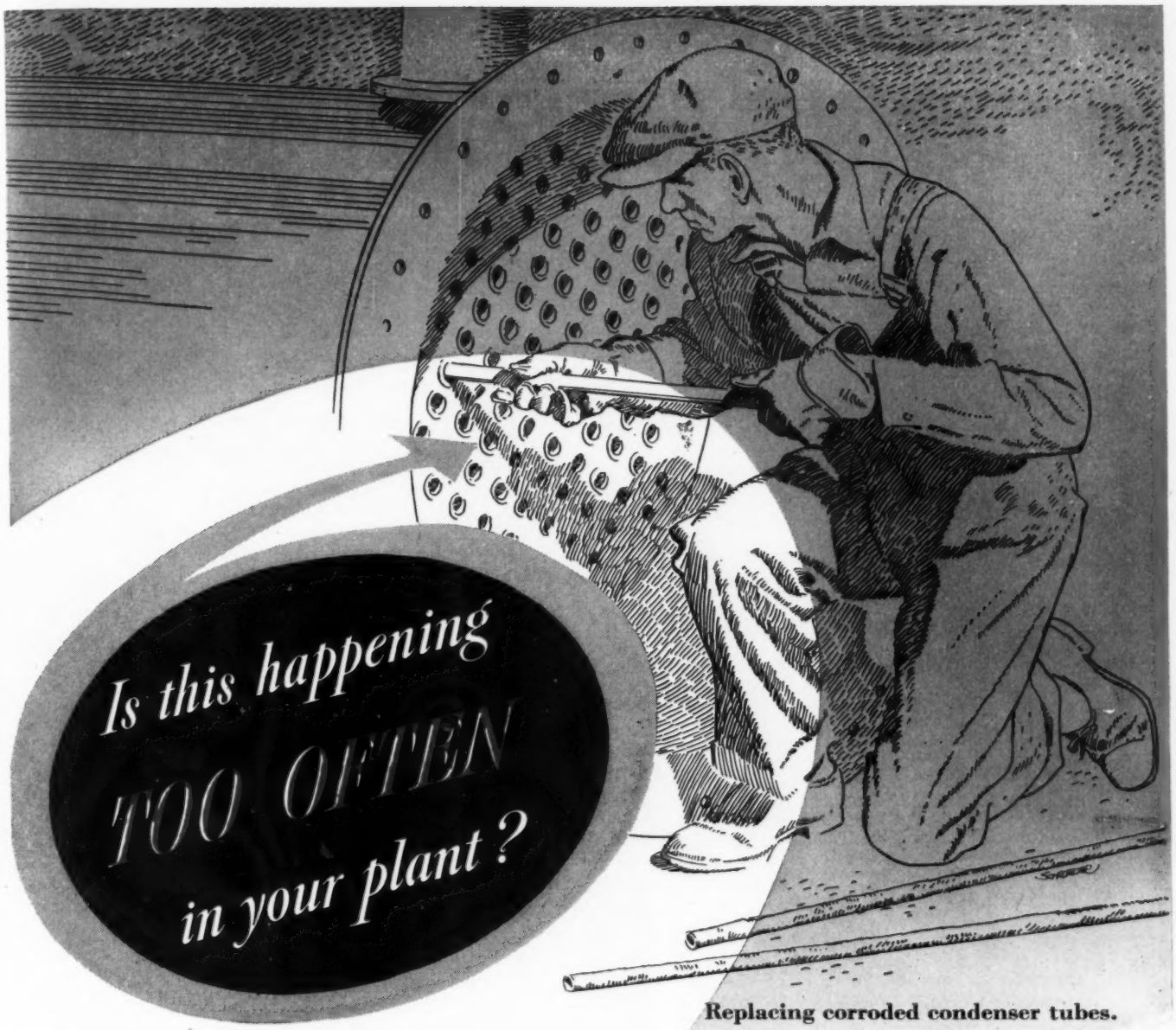


Fig. 1—Flow diagram of process for sweetening petroleum distillates, in which air regeneration of the caustic solution is controlled so that the regenerated caustic retains a small but essential amount of mercaptans sufficient to prevent destruction of the catalyst (U. S. 2.413.945)



Replacing corroded condenser tubes.

Condenser Tubes of Alcoa Alclad Aluminum may be the answer to your corrosion problems

The idea's not new. Condenser tubes of Alcoa Aluminum are already employed in all manner of processing plants. The aluminum safeguards product quality. And it offers high resistance to the attack of corrosive cooling waters and of materials being processed.

Now, a new development in tubing is offered —Alcoa Alclad—strong aluminum combined with a highly protective interior coating of aluminum. An even greater number of gases and liquids can be handled by aluminum condenser tubes than before.

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ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM

24,000 GMV HORSEPOWER at Lion Oil

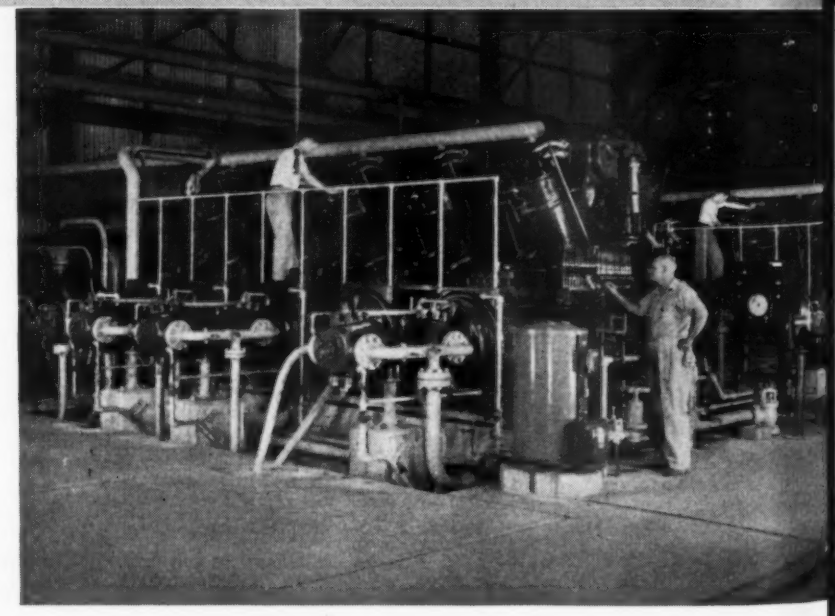
From Blockbusters to Famine-busters!

HERE is an example of how America's engineering and production ingenuity can often convert machinery of war into peacetime instruments for nation-wide, even world-wide betterment.

In this vast ordnance plant, originally dedicated to wartime destruction, big Cooper-Bessemer engine-driven compressors are still helping to produce synthetic ammonia from natural gas. Up to 500 tons are produced here daily . . . but no longer for the making of high explosives. It is now converted into ammonium nitrate fertilizer.

There are of course hundreds of important uses for ammonia. Used for conversion to critically needed fertilizer, it will go far as a "famine-buster" to help grow crops to feed a hungry world.

This is one of the largest compressor installations ever made — 24 Cooper-Bessemer 10-cylinder gas engines, delivering 24,000 compressor horsepower. During the war years and on into peace these units have been demonstrating the long-range dependability and efficiency that GMV users in *all* fields have learned to expect from these modern Cooper-Bessemers.

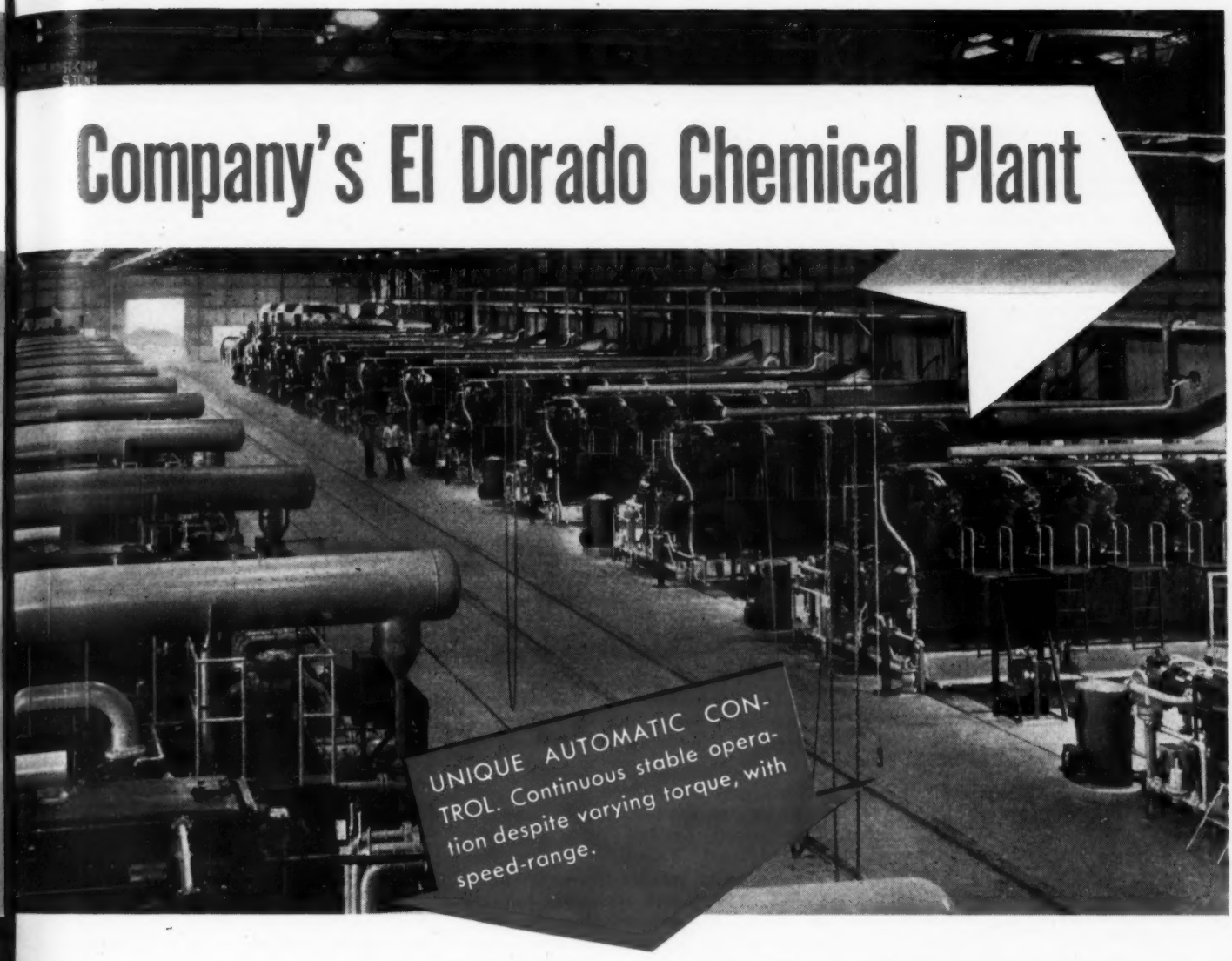


Close-up of one of the 24 GMV's installed at Lion Oil Company's El Dorado Chemical Plant. Twelve, of which this is one, are high-stage units automatically controlled to match exactly the process demand at all times.

TYPE GMV ANGLE Compressors

New York Washington Bradford, Pa. Houston, Dallas, Greggton, Pampa and Odessa, Texas Los Angeles

Company's El Dorado Chemical Plant



One feature of this big, 24-unit compressor installation is the system of automatic control. Two pneumatic pressure controllers regulate the speed of 12 of the compressor engines from 150 to 300 rpm to maintain a constant suction pressure to the 12 high stage compressors.

This type of automatic control successfully holds pressure or flow rate within an accuracy of 1%, with the least possible disturbance to the balance of the process. Due to low engine speeds, fuel and maintenance costs are exceptionally low. Instead of the conventional hydraulic or mechanical governor, Cooper-Bessemer's patented Exact Rate Governor speed control is used. It is ideal in this kind of installation, offering many advantages where continuous stable operation is necessary under varying torque and over a wide speed range. There is no appreciable "dead" zone of control correction. The rate of fuel correction, after a speed deviation, is not fixed, but is proportional to the rate of deviation. The instrument adjustments permit the rate of correction to be better regulated for the individual engine. Also, the Exact Rate Governor control permits direct, manual regulation of the amount of fuel for starting, resulting in easier, quieter, and *better* starting.

These are only a few of the advantages this one Cooper-Bessemer feature is bringing to various users in the chemical and petroleum industries. And it is only one of many outstanding GMV features.

by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Parkersburg, W. Va. San Francisco, Calif. Seattle, Wash. Tulsa Shreveport St. Louis Caracas, Venezuela

TABLE 1—Treatment Methods and Products from Barrer Method (U. S. 2,413,134) for Making Selective Absorbents

No.	Raw mineral	Treatment	Temperature	Product
1	Barium aluminosilicate gel, $BaAl_2Si_4O_{12}xH_2O$.	Three days' heating with concentrated aqueous $BaCl_2$	235° C.	Good yield of mineral with occluded $BaCl_2$.
2	Barium aluminosilicate gel as above.	.... do	270° C.	Moderate yield only of mineral. Occluded $BaCl_2$.
3	Synthetic analcite $NaAlSi_2O_6H_2O$.	Six progressive treatments with concentrated aqueous $BaCl_2$, each lasting about one day.	210° C.	Excellent yield of mineral. Occluded $BaCl_2$.
4	Naturally occurring analcite, $NaAlSi_2O_6H_2O$.	Five progressive treatments with concentrated aqueous $BaCl_2$, each lasting 12 hours. Analcite mixed with half its volume $BaCl_2$ and with half the total apparent solid volume of water.	200° C.	Do.
5	Naturally occurring analcite as in 4.	Four progressive treatments with concentrated aqueous $BaCl_2$, each lasting about 1 day.	233° C.	Good to moderate yield of mineral. Occluded $BaCl_2$.
6	Potassium aluminosilicate gel, $KAlSi_2O_6xH_2O$.	Six days' heating with concentrated aqueous $BaCl_2$	180° C.	Excellent yield of mineral. Occluded $BaCl_2$.
7	Ca-base-exchanged gel zeolite—"Doucil."	(*a*) Six days' heating with concentrated aqueous $BaCl_2$	180° C.	Crystallization not marked.
		(*b*) Five days' heating with concentrated aqueous $BaCl_2$	208° C.	Excellent yield of mineral. Occluded $BaCl_2$
8	Gel zeolite—"Burgess Freeze-Formed Zeolite."	Five days' heating with concentrated aqueous $BaCl_2$	208° C.	Good yield of mineral. Occluded $BaCl_2$.
9	Barium aluminosilicate gel, $BaAl_2Si_4O_{12}xH_2O$.	One day's heating with concentrated aqueous $BaCl_2$ at 210° C. followed by two days' further heating at 197° C.	.....	Do.
10	Synthetic analcite, $NaAlSi_2O_6H_2O$.	Two days' heating with concentrated aqueous $BaBr_2$	204° C.	Good yield of mineral. Occluded $BaBr_2$.

not redissolved in the gasoline, nor are they removed readily by the air in extractor 11 and thus serve to protect the regeneration catalyst without interfering with the removal of mercaptans in the gasoline.

Selective Absorbents by Hydrothermal Methods

SOMETIME ago,[2] there was discussed some work carried out by Barrer in England on the "sieving" of hydrocarbons structurally by means of specific absorbents such as chabasite. For example, by means of such crystalline zeolites, it is possible to occlude *n*-paraffins to practical exclusion of branched chain hydrocarbons admixed therewith.

Unfortunately, absorbents of the chabasite type occur naturally only in limited quantities, so that a number of firms have been busy attempting to produce synthetic products having similar properties.

In his U. S. 2,413,134, Barrer states that the zeolite analcite can be readily produced by crystallizing gel mixtures having the composition $NaAlSi_2O_6 \cdot nH_2O$.

Such gels are made by mixing $NaOH \cdot Al(OH)_3$ and $Si(OH)_4$, or by stirring water-glass and sodium aluminate solutions which are allowed to stand for about 24 hrs. at 200° C. to allow the analcite to crystallize. It is not a suitable selective absorbent, but it can be modified to serve the purpose.

Barrer has developed a hydrothermal method, using concentrated aqueous barium salt solutions, for making crystalline molecular sieve absorbents having properties similar to those of chabasite. The aluminosilicates, analcite and leucite, are altered hydrothermally by heating at elevated temperature with excess barium chloride or bromide solution, and extracting with water the occluded salt products, followed by dehydration by heating.

Good gels have been obtained by employing, as the initial gel, "Burgess Freez-Formed Zeolite," or a calcium-base-exchanged "Doucil." Usually the procedure is to powder the zeolite raw material, mix it well with one half to one and a half times its volume of solid barium chloride or bromide, add water amounting to one half to one times the total solid, and heat in an autoclave at 180-270° C. for two to six days. The product is extracted with water at 180-270° C. in an autoclave to remove occluded salts. Table 1 gives some results obtained with various raw materials.

Asphaltic Weed Killer

DURING the past year[1] Socony-Vacuum has been credited with the development of a petroleum hydrocarbon weed killed (Sovasol No. 75), a light distillate, said to leave no taste or odor on vegetables, and destroying weeds among carrots, parsnips, and parsley.

A recent patent issued to Standard Oil Development Co. (U. S. 2,414,640) discloses the permanent killing of weeds along roadsides and protecting of the area against reseeding by providing an impervious surface. It is pointed out that although asphalt and similar petroleum products exhibit a scorching effect on weeds, they do not effect a permanent cure. This is illustrated in the case of the Mississippi River revetment work wherein weeds were known to force their way through the asphaltic mat.

Highly aromatic asphaltic material has been found highly toxic to weed growth and the higher gravity of such products makes them more resistant to water displacement. A blend of 35-65% asphalt with 65-35% solvent has been found suitable, although a 60% asphalt-40% solvent blend is advisable on new constructions to avoid the growth of vegetation due to the presence of weeds in the adjacent area.

References

(1) Gaylor, *Technical Survey*, 1945, p. 366, 520.
(2) Ibid., p. 360.

Selected Patents of the Month

U.S. 2,412,589 (Standard Oil Development)—Alkylating resins.
U.S. 2,412,595 (Phillips Petroleum)—Alkylating benzene.
U.S. 2,412,600 (Standard Oil—Ohio)—Gel type catalyst hydrocarbon treating.
U.S. 2,412,633-4 (Standard Oil—Ind.) — Sulfurized lubricant.
U.S. 2,412,645 (Standard Oil Development)—Aviation gasoline.
U.S. 2,412,675 (Universal Oil Products) — Isomerization.
U.S. 2,412,679 (Standard Oil—Ind.) — Sulfonates and sulfonyl chlorides.
U.S. 2,412,762 (Cities Service)—Butadiene from propene and formaldehyde.
U.S. 2,412,791 (Petrolite) — Removing water from oil.
U.S. 2,412,828 (Texas Co.)—Extracting aromatics.
U.S. 2,412,863 (Socony)—Circulation and contacting of acid catalysts.
U.S. 2,412,868 (Standard Oil Development)—Subjecting cat. cracking catalysts to ammonia.
U.S. 2,412,880 (Phillips Petroleum)—Azeotropic distillation of butadiene and 2 butene.
U.S. 2,412,903 (Calif. Research Corporation)—Lube oil containing Zn thiocarbamate.
U.S. 2,412,911 (Standard Oil Development)—Butadiene from butene-2.
U.S. 2,412,916 (Standard Oil Development)—Petroleum detergent for shampoo.
U.S. 2,412,929 (Crane Co.)—Grease.
U.S. 2,412,956 (Elgin Nat'l Watch)—Lubricant containing alkyl piperidine salts.
U.S. 2,412,958 (Houdry Process)—Production of inorganic gel contact material.
U.S. 2,412,983 (Hene)—Conversion of heavy hydrocarbons, using molten surface.
U.S. 2,413,105 (Texas Co.)—Alkylation.
U.S. 2,413,121 (Standard Oil—Ind.) — High temperature greases.

Portable Weld Fume Exhauster Has Filter and Spark Arrestor

In addition to the portable welding fume exhauster described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have recently been issued include:

- **Check valve in foam branch pipe prevents oil escape**
- **Build concrete tank in 8 hours by use of inflated bag forms**
- **Carbon dioxide used in novel high-temperature plug valve**
- **New Flowmeter is adaptable to either liquids or gases**
- **New harness simplifies rescue of workman**

A PORTABLE welding fume exhauster with self-contained filter and spark arrestor, and light enough for one man to carry about from job to job, is said to make possible frequent repair jobs scattered around the plant and especially those in small, confined, and almost inaccessible locations.

Shown in longitudinal section in Fig. 1, the unit is operated as follows: A flexible hose placed at the welding operation carries fumes to inlet 7. Fumes pass into the exhauster, striking baffle 37, which causes heavy particles to drop out and settle in chamber 36. Fumes pass on through spark arresting screen 34 and ports in plate 17, thence into tubular bags 18. The bags remove the remaining particles and dust, while the filtered fumes are drawn out by fan 9, passing out to the atmosphere through openings in the rear housing 12.

Dust is removed from bags 18 by placing the unit in a vertical position with the fan at the top. Cord 23 is released from hook 24 and jerked. This results in an up and down motion of the bags, shaking dust down into chamber 28, from which it can be easily removed through slide opening 29.

In normal operations, the bags are held taut by tension of springs 22, attached to base plate 17 and support 21. The broken lines near the center of the drawing indicate the position of support 21 when line 23 is released.

U. S. 2,414,564, issued Jan. 21, 1947, to Leslie Silverman and Frederick J. Viles, Jr., Boston, Mass.

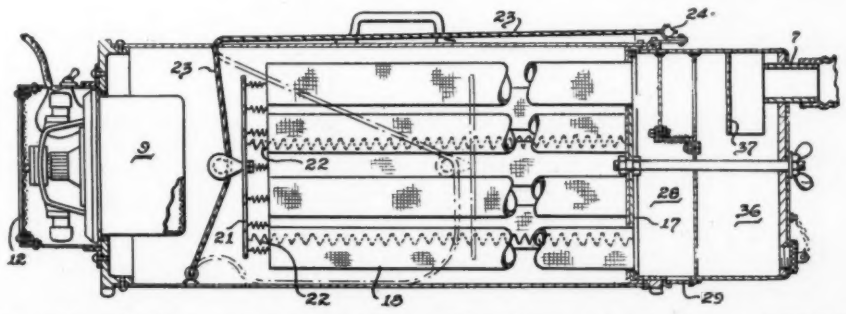


Fig. 1—Longitudinal section of portable welding fume exhauster (U. S. 2,414,564). Fume inlet is at 7, exhaust fan at 9, filter bags at 18

Check Valve in Foam Branchpipe Prevents Oil Escape from Tank

FIRE EXTINGUISHMENT equipment designed to introduce foam into the bottom of an oil or gasoline storage tank through the regular pipe for transferring material can be improved by an automatic check valve in the foam line. It is said to overcome the possibility of oil leaking out through the air intake in the foam line should the pressure in that line fail or diminish.

A plan view of a typical oil tank installation with foam branchpipe in position is shown in Fig. 2. Transfer line 2 enters tank 1 at the bottom and includes gate valves 3, 5, and 8, and Y-fitting 4. Line 6 is the regular oil line. Foam is introduced when needed through valve 8. The branchpipe 9 contains the automatic check valve and means for forming foam, and is shown in detail in Fig. 3.

Foam-producing solution enters from line 12, passes through a jet-producing head 11, cone 13, throat 14, flare 15, receiver 16, and on through valve 8 into the tank. The head 11 is surrounded by a conical hood 17, which is open to the atmosphere and through which air is drawn in by the jet.

The check valve action is provided by ball 18 in cage 19. When foam is being produced the ball is forced away from throat 14 by the foam. If the flow tends to reverse, the ball moves back and closes the throat.

Because ball 18 may occasionally stick at the forward end of cage 19, a device is provided for dislodging it manually. The operator pulls on handle 27 of rod 25, thereby moving rod 20 inside the cage, and dislodging the ball.

A variation of the device uses an ordinary clap type check valve at the end of flare 15. In this case, a lever is also provided for releasing the clap, should it become stuck.

U. S. 2,414,260, issued Jan. 14, 1947, to John N. Hunter, Brentford, England, assignor to The Pyrene Co. Ltd., Brentford, England.

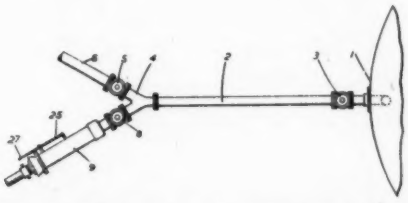


Fig. 2—Plan view of typical installation for bottom-of-the-tank introduction of fire-fighting foam (U. S. 2,414,260).

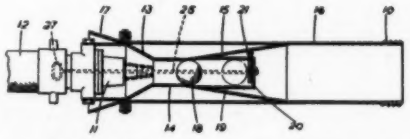


Fig. 3—Detailed view of check valve and foam-forming apparatus shown at branchpipe 9 in Fig. 3

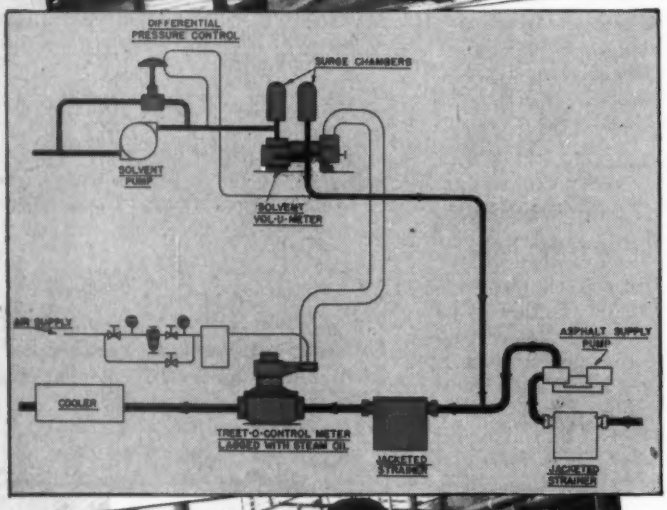
Build Concrete Tank in 8 Hours By Use of Inflated Bag Forms

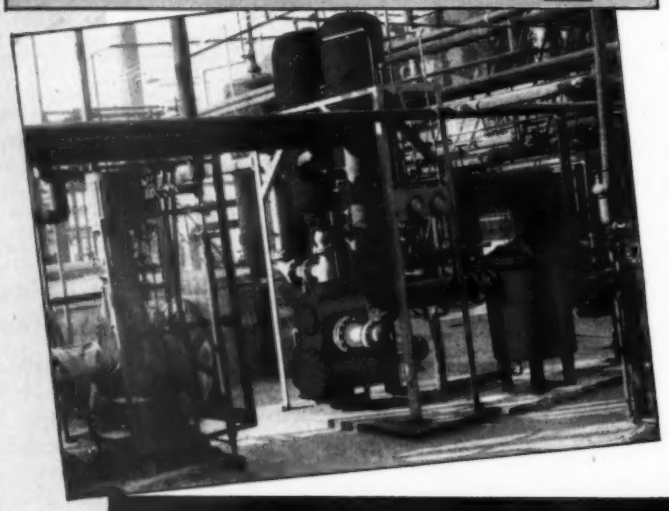
CONCRETE underground storage tanks for gasoline, fuel-oil, and similar materials can be constructed in eight hours by the use of inflated fabric bags as forms, it is claimed.

Originally devised as an aid to speeding up military operations of supply, the invention could be economically adapted to use in peacetime oil industry operations. One form of tank—semi-spherical—is shown in Fig. 4. Other shapes—full-spherical, cylindrical, and the like—may be constructed by the same method.

The bag, which may be made of such materials as nylon, tire cord fabric, high-

Clean Up Your Asphalt Blending Operation





%PROPORTIONEERS% CONTINUOUS PRODUCTION METHOD CONFINES ALL FLUIDS IN PIPE LINES THROUGHOUT PROCESS

These views of the %Proportioneers% continuous, automatic, cut-back installation at the General Petroleum Corporation Asphalt Refinery in Vernon, California, indicate the cleanliness and compactness of this modern method. Open tank mixing and the fire hazard due to foaming are entirely eliminated. Less tankage is required for storage since blending is performed as a continuous process and batches can be delivered direct to tank cars. Rehandling is avoided, with consequent savings in time, power, equipment and evaporation loss. By means of this highly flexible %Proportioneers% system, one operator can . . . with a single adjustment . . . continuously reproduce any cut-back having a viscosity within specification limits.

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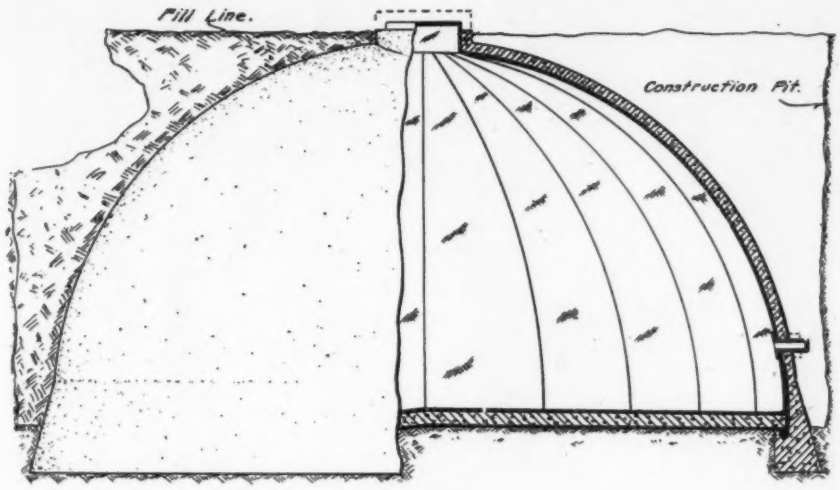


Fig. 4—Method of constructing concrete underground storage tank (U. S. 2,413,243) by use of inflated fabric bag as primary form

thread-count cotton muslin, or cotton duck, is inflated to low pressures, up to 2 oz./sq. in. Then a preliminary shell, functioning as a secondary form, is built up by spraying on the surface of the bag a fast-setting material such as gypsum plaster to a thickness of approximately ¾ in.

The inflation pressure is maintained until this thin layer has set, resulting in a self-sustaining shell capable of supporting the load of concrete then placed by any suitable method.

A tank with a floor diameter of 22 ft. provides about 20,000 gal. capacity in the form shown in Fig. 4, with a shell thickness of about 3 in. Reinforcing steel is unnecessary because of the arch type construction and the monolithic character of the concrete.

The fabric form is left in place after the concrete has set. It is then treated with synthetic rubber, resistant to the solvent effect of the liquid to be stored. The outer surface of the tank is treated to resist soil action.

U. S. 2,413,243, issued Dec. 24, 1946, to Wallace Neff, Los Angeles.

Carbon Dioxide Used in Novel High-Temperature, Plug Valve

Carbon Dioxide is used to improve seating by internal pressure in a hollow plug-type, high-temperature valve, capable of functioning satisfactorily up to about 1400° F.

As shown in Fig. 5, the valve body is represented by 1, the seat by 2, the plug by 3. The arrows indicate the direction of flow. Plug 3 is of a flexible metal, between 1/32 and ½ in. in thickness, depending on the size of the valve.

In fabrication, enough solid carbon dioxide is placed in the plug so that during operation over the expected temperature range, the pressure inside the plug will exceed the pressure of the fluid passing through the valve.

When the valve is closed, there will be a drop in pressure on the downstream side of the valve. The consequent increased differential between internal and external pressure on the downstream side will cause a slight expansion of the plug shell, thereby increasing the seating pressure and maintaining a tight seal.

U. S. 2,412,913, issued Dec. 17, 1946, to Leo W. Schrader, assignor to Standard Oil Development Co.

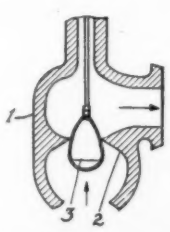


Fig. 5—Plug 3 in this high-temperature valve (U. S. 2,412,913) contains carbon dioxide, assuring tight seal under such conditions as 1400° F.

New Flowmeter Is Adaptable To Either Liquids or Gases

Fluid Flow is measured in a meter consisting simply of a transparent tube containing a freely-moving sphere, and based on a principle similar to the well-known rotameter type of flowmeter.

Said to be equally adaptable to either liquids or gases, the instrument is shown in Fig. 6. Fluid enters line 7, passes through transparent tube 1, and leaves via line 12. The tube 1 may be composed of any material suited to the properties of the fluid being measured, and is preferably in the shape of a circular arc, though it may be a parabola or a segment of a logarithmic curve.

The fluid carries sphere 2 toward the outlet end until force f-2, a function of the fluid flow, is equivalent to force f-1, a function of the pull of gravity, at which point the sphere assumes a stationary position.

The graduated scale 3, attached to tube 1, is calibrated for the type of material for which flow is to be measured.

U. S. 2,413,352, issued Dec. 31, 1946, to Herbert A. Hulsberg, assignor to Universal Oil Products Co.

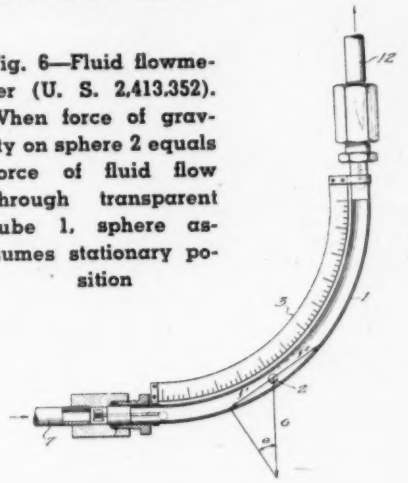


Fig. 6—Fluid flowmeter (U. S. 2,413,352). When force of gravity on sphere 2 equals force of fluid flow through transparent tube 1, sphere assumes stationary position

New Rescue Harness Simplifies Removal of Workmen from Tanks

A New Type rescue harness which pulls an unconscious man from a fume-filled tank by the arms and in a suspended position is said to overcome the difficulties encountered with the conventional harness, which is attached to the man's back.

As shown in Fig. 7, the top of the tank is represented by 10 and the manhole by 9. Safety line 8 passes through ring 6 and is attached to ring 7 on the straps 1 on the worker's wrists. The line 8 is kept slack while the man is working, and is said not to interfere with his activities.

U. S. 2,413,903, issued Jan. 7, 1947, to Vernon L. Beehler, Lewiston, N. Y.

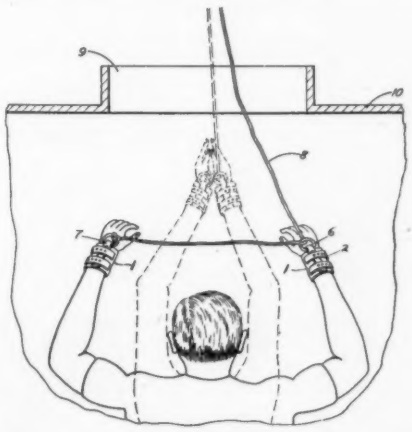
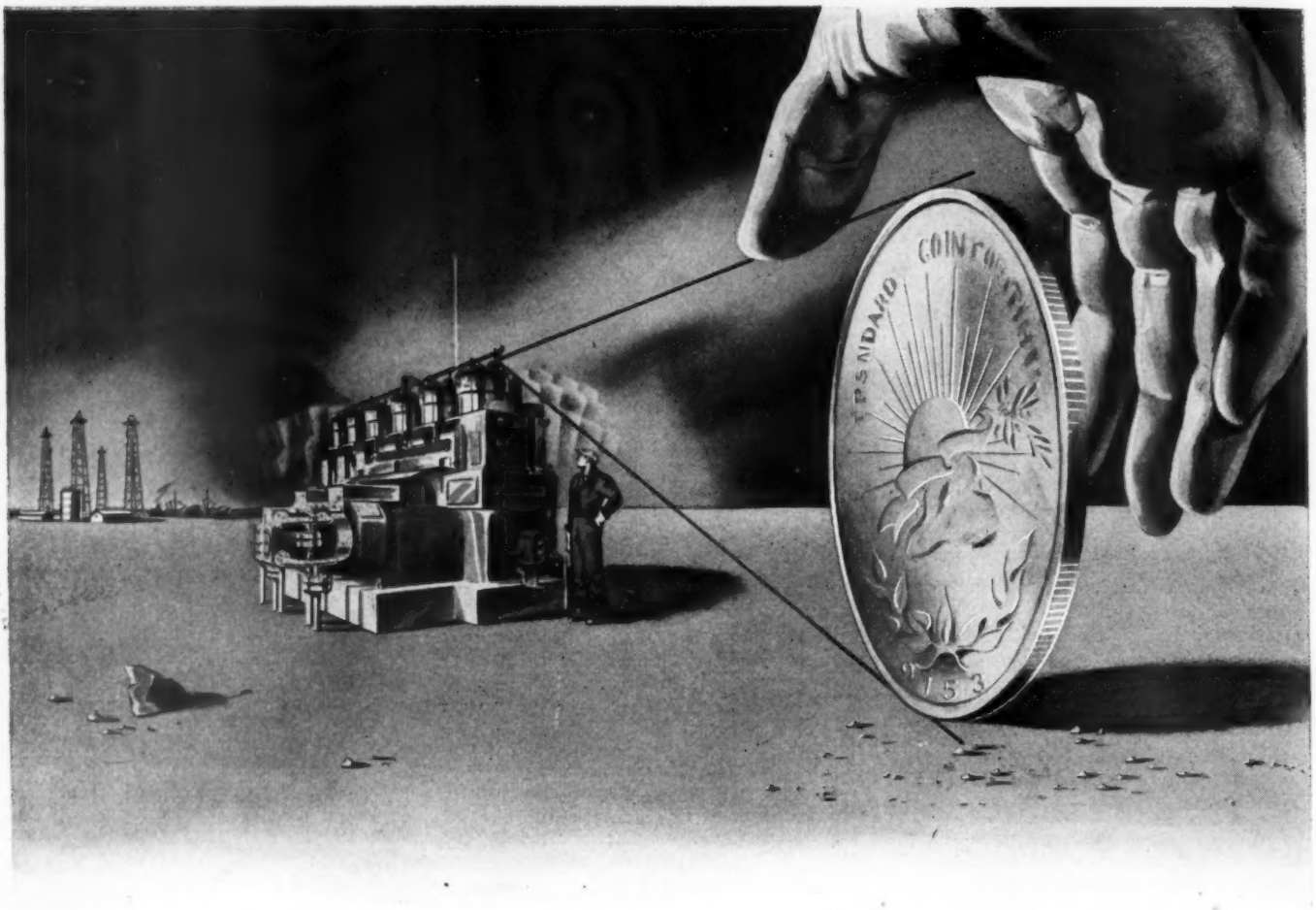


Fig. 7—New type rescue harness (U. S. 2,413,903) pulls unconscious workman from tank in a straight body, suspended position, with arms overhead



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Converted Topping Unit Makes Close-Cut Naphthas and Solvents from Gasoline

How Idle Topping Equipment in One Refinery Has Been Remodeled and Put Into Profitable Operation to Produce Products for which a Good Market Exists

THE end of the war found Republic Oil Refining Co. with an old topping unit on its hands which would not be needed in the contemplated reconversion of its Texas City refinery from war to peace. The topper was the No. 1 unit at the plant having been the first piece of equipment erected when the plant was built.

As the topper still was in "run-able" condition, decision was made to convert it to the manufacture of petroleum naphthas and solvents from straight-run gasoline, for which a good market exists. The resulting unit now produces 930 to 1550 b/d of solvents from 1500 to 2000 b/d of charge, plus a gasoline blending stock and a light ends fraction. Part of the light ends fraction is sold for chemical manufacture and the balance incorporated into motor fuel.

The solvents produced fall into three groups: "Naphthol" mineral spirit (290-340° F.), "Lactol" spirit (200-240° F.), and "Textile" spirit (140-200° F.). The "Naphthol" mineral spirit belongs to the varnish makers and painters solvent group of petroleum solvents and is too light to be considered a Stoddard (cleaner's) solvent. Its principal uses are as a thinner for paints, varnishes, enamels, and polished, and possibly in insecticides. The "Lactol" spirit, as well as its close cousin, the "Textile" spirit, are principally used in making rubber cements, as a substitute for alcohol in sealers and shellacs, as a lacquer diluent, and in printer's inks.

The most unusual feature of the plant is securing close cuts between fractions—about a 2° F. gap in boiling range exists beween end point of the overhead product and initial of the bottoms material—with three towers containing from a minimum of nine to a maximum of 14 trays in any one fractionator. One of the worst operating headaches, also, was in prevention of flashing a tower dry or securing adequate reboil heat using idle equipment available in the refinery.

The unit proper consists of a stabilizer, a gas-fired heater and three towers, two having 14 trays each and the other, nine. The stabilizer originally was a pressure distillate stabilizer in the old plant, used during wartime operation to stabilize 91 octane aviation gasoline. The primary fractionator, 8-ft. x 45-ft., 14 trays, was the flash fractionator on the original topper; the secondary fractionator, 6.5-ft. x 48-ft., 14 trays, was the original topper fractionator. The third or "Naphthol" fractionator originally was a rich-oil stripper operated in conjunction with the plant's first gas recovery unit. These facilities are shown in the accompanying photographs.

Conversion to make solvent naphthas consisted largely of piping rearrangements to connect the two largest towers in series for a total of 28 trays of fractionation and provide for necessary reboil heat. Also, control equipment had to be provided, since control was a must in the close separations desired. Flow in the unit is shown in Fig. 1.

Process Operation

Charge consists of straight-run gasoline from the crude topping units, which operate on sweet Coastal crude. It receives a caustic wash before being charged. This enters a conventional stabilizer under 55 psi and a C_3 to 140° F. end-point cut is taken overhead. Inspection of stabilizer charge is given in Table 1.

Stabilizer bottoms enter the primary fractionator, operating at 16 psi, splitting into a 140-240° F. overhead and a 240-340° F. bottoms. Bottoms are circulated through a gas-fired tubular heater and raised to 410-415° F., a part of this stream returning to the primary fractionator as reboiler cycle stock while the balance is charged to the "Naphthol" tower.

Charge to the secondary fractionator is overhead make from the primary

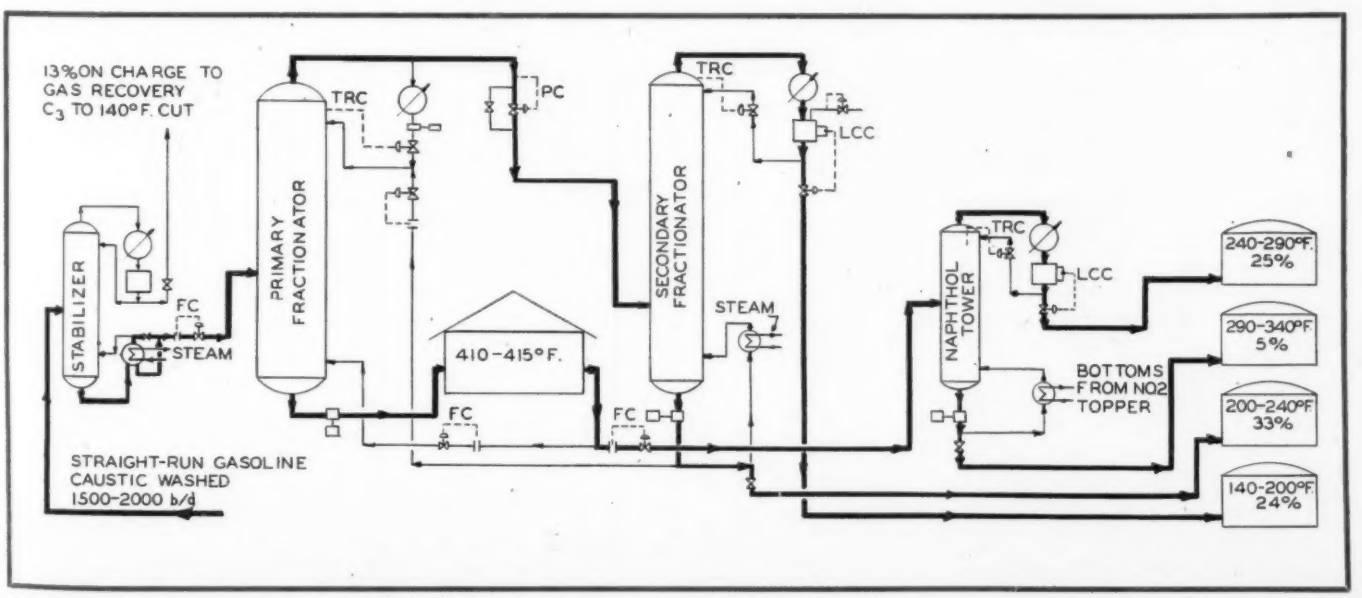
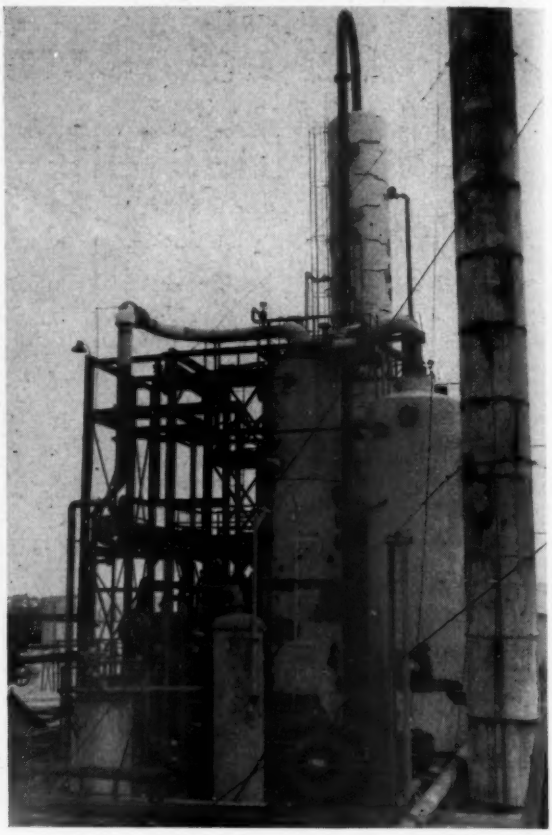


Fig. 1—Flow diagram of solvent naphtha unit at Republic Oil Refining Co.'s Texas City refinery. Built from an idle topping unit, it produces three solvent cuts and two by-product streams from straight-run gasoline

RIGHT—View of solvent distillation unit which formerly was an idle, outmoded topping still. Smallest (black) tower, barely visible at left, is straight-run gasoline stabilizer. Shortest white tower, next to it, is the "Naphthol" tower, then secondary and primary fractionators. Tall column in background is No. 2 topper bubble tower, not connected with solvent unit



BELOW—Pumphouse at the unit; existing pumps were used primarily

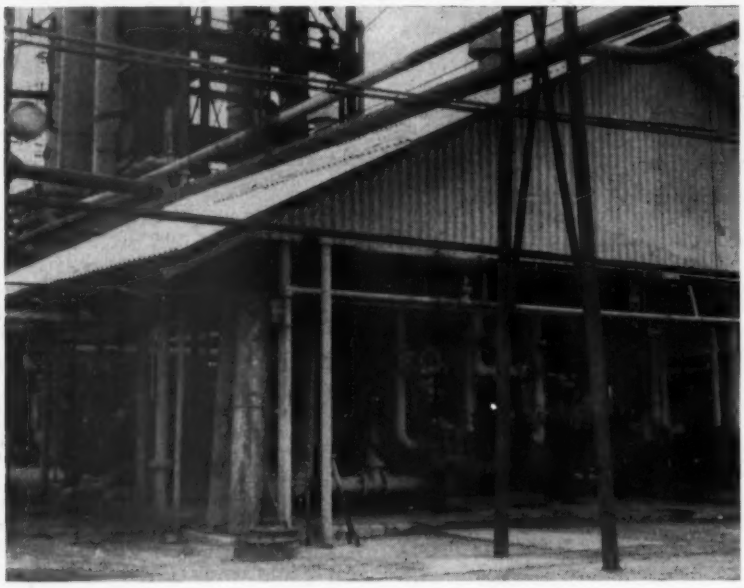


TABLE 1—Inspection of Naphtha Unit Charge Stock*

Gravity, °API	55-58
ASTM Distillation, °F.	
IBP	111
5%	173
10%	189
50%	234
90%	292
End point	332
Corrosion, full distillation, Cu strip	Pass
Doctor Test	Sweet
Color, Saybolt	+30

* Caustic washed S-R gasoline from sweet Coastal crude.

tower, a 140-240° F. cut, which is split into a 140-200° F. cut-so-called "Textile solvent"—overhead and 200-240° F. bottoms. A portion of the bottoms from the secondary fractionator is returned as reflux to the primary tower. Reboil heat to this secondary tower is furnished by a steam-heated exchanger, with a large percentage of the heat supplied by the bottoms reflux to the Primary Tower. This was done in order to keep the bottom section of the tower stable.

In fact, much of the reflux to the primary tower is cycled bottoms from the secondary fractionator, the operation in effect picking up heat from the primary column and supplying it to the secondary tower with the charge. In early operation, this bottoms line did not exist and as a consequence the reboiler either supplied too much or not enough heat to the secondary tower, alternatively flashing the tower dry or permitting it to flood. Now the reboiler is used to supply only the additional increment of heat to the tower for proper temperature control. The pressure controller in the charge line to this secondary tower is by-passed in present operation.

The bottoms from the secondary tower is withdrawn as "Lactol" spirit, or 200-240° F. cut.

A slip stream from the primary tower reboiler transfer line, leaving the heater at 410-415° F., is the charge to the "Naphthol" tower. Overhead constitutes the 240-290° F. cut and bottoms the 290-340° F. cut. Bottoms from No. 2 topping unit is used to supply reboil heat for this operation. The 240-290° F. cut is not now salable as a petroleum solvent, and is utilized in blending motor gasoline; it constitutes approximately 25% of the original charge stock.

An inspection of the three solvent naphtha cuts made on this unit is given in Table 2. Specifications will not permit an overlap between initial point of the bottoms and end-point of the overhead.

It has been suggested that this equipment be used to prepare an aromatic solvent from catalytically cracked gasoline. The operation is not regarded as profitable, however, since this fraction possesses a high octane rating and eliminating it would seriously reduce clear octane number of plant's finished motor fuel. Alkylate is not available under the refinery's present operation.

TABLE 2—Inspection of Solvent Naphtha Fractions

ASTM Distillation, °F.	Textile Spirit	Lactol Spirit	Naphthol Mineral Spirit
IBP	140	200	290
10% (min.)	150	205	295
50% (max.)	175	220	310
80% (min.)	...	...	...
90% (max.)	190	230	325
End point	200	240	340
Aniline No., °F.	135	135	135
Flash, T. C. C.* °F.	...	...	85
Corrosion (full distillation, Cu strip	Pass	Pass	Pass
Doctor Test	Sweet	Sweet	Sweet
Color (min.), Saybolt	+25	+25	+25
Odor	Good	Good	Good

* "T. C. C." above means "Tagliabue Closed Cup" method.

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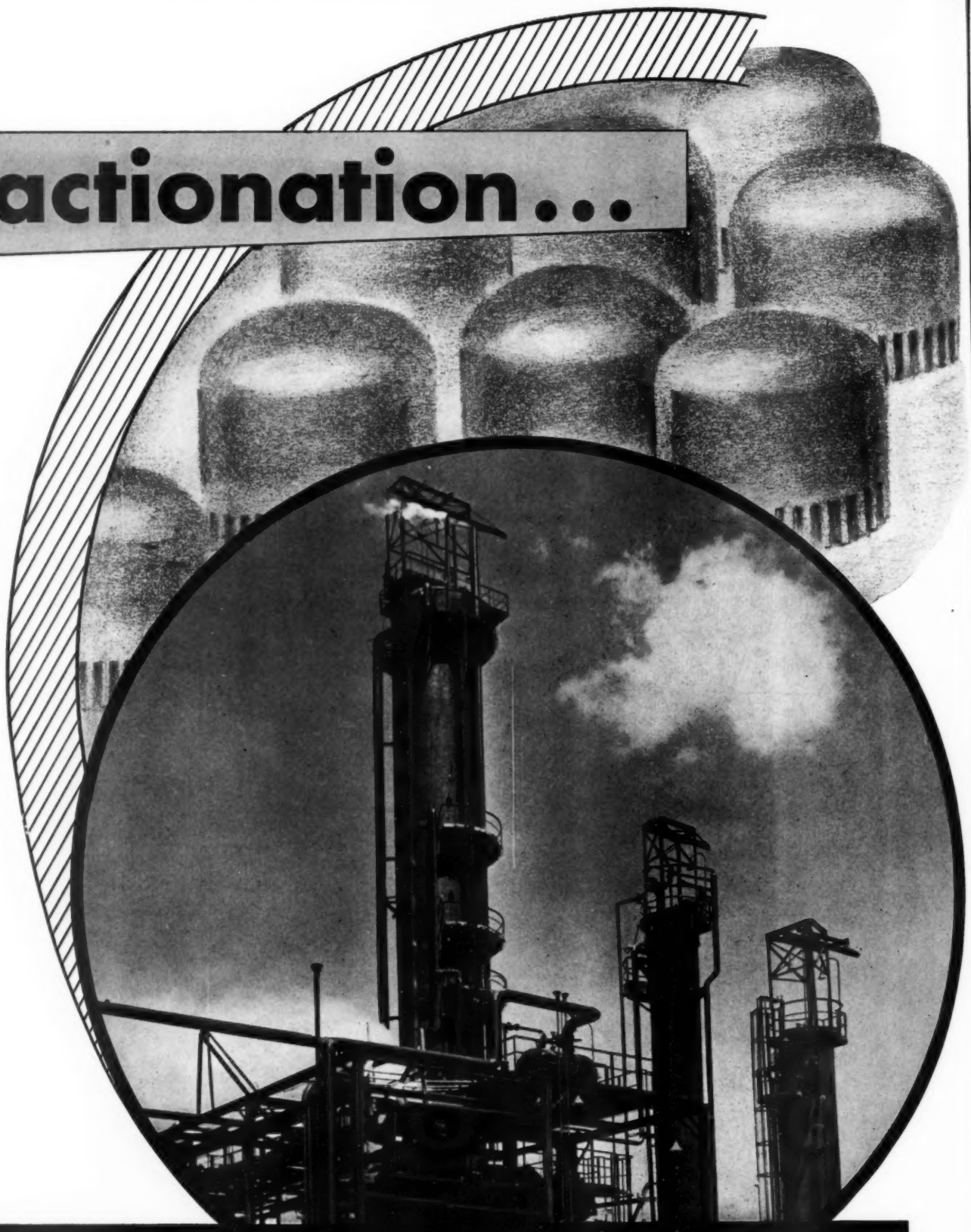

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Basic Natural Law—not "Rule-of-Thumb" Should Apply in Sedimentation Methods

Article 15 in a Series—By W. B. HART
In Charge of Waste Disposal for Atlantic Refining Co.

The design of equipment for separating oil from oily waste before its discharge into unpolluted streams should be based on known physical laws governing sedimentation phenomena.

Such laws include those concerning the rate of sedimentation, which is affected primarily by the oil globules being formed, their size, shape, and path of travel. These factors in turn depend upon the viscosity and surface tension of the oil.

Most practical applications in refineries of sedimentation procedures are on continuous rather than batch methods; however, the same fundamental principles govern either type of separation. The chief goal in design of equipment is to approach ideal conditions of sedimentation as determined by the natural laws.

THE underlying principle of practically all treatment methods for oily waste waters is the separation and retention of the oil so that the waste water can be discharged without causing pollution. The effects of oil on or in surface waters have been described.

There is no definite regulation as to the permissible quantity of oil in waste waters to be discharged into surface waters over the country. Some years ago it was rather usual for federal and state agencies to accept 30 parts per million as satisfactory. More recently, however, much lower figures are regarded as necessary. In some sections of the country, 10 parts, or even 5 parts per million are required. To meet these requirements somewhat intricate treatment methods must be employed. Equally involved methods may be necessary at times to prepare a waste (i.e. remove oil) for treatment to remove some other obnoxious component or characteristic.

The treatment procedures employed for the removal of oil from oily wastes have as their fundamentals sedimentation, precipitation of emulsifying agents, neutralizing of electrical charges, filtration, flocculation, and biological oxidation. Variations and combinations of these procedures also are employed.

To all intent and purpose, petroleum and its products are immiscible with water. The separation of oil from water is simple, as is evidenced by the pencil tops containing a globule of oil in water which have been used extensively for advertising. Anyone familiar with these will know that when the pencil is inverted, the oil globule promptly rises to the top, and the water is perfectly clear below. Obviously, the oil could be skimmed off readily.

The reason that this complete separation takes place so readily is that the conditions are right, and the natural laws which govern sedimentation can operate without interference. In the past, judging from the design of separation equipment, the phenomenon of sedimentation was treated in a rather "rule of thumb" (or worse) manner. Apparently, little or no attention was accorded known natural laws or the empirical designs established by sanitary engineers for sewage treatment.

Rate of Sedimentation

There are a number of factors which govern the separation of oil from water by sedimentation under conditions which are applicable to the treatment of refinery waste. Probably the best method for presentation of these factors is by analysis of the governing laws. Of these, the law which governs the rate of sedimentation should come first.

In his experiments which were performed to develop a method for measuring viscosity, Stokes [159] proved that a sphere impelled by a constant force, F, in a viscous liquid, eventually assumes a constant velocity, V. He also proved the validity of the linear relationship:

$$F = 6\pi\eta r V \quad \ldots\ldots (1)$$

in which:

F = the impelling force
π = 3.1416
η = the coefficient of viscosity in dynes/sec./sq.cm (absolute viscosity in poises)
r = the radius of the sphere
V = the velocity.

The most important application of this relationship in connection with sedimentation is that in which the sphere falls or rises through the liquid as a result of its weight or buoyancy. The force then can be evaluated by use of the equation:

$$F = \frac{4}{3}\pi r^3 g(\rho - \rho_1) \quad \ldots\ldots (2)$$

in which:

g = the gravity constant (980 cm./sec./sec.)
ρ = the density of the material composing the sphere
ρ_1 = the density of the liquid.

By combining Equations 1 and 2 the resulting equation expresses Stokes' Law and is obtained as follows:

$$\frac{4}{3}\pi r^3 g(\rho - \rho_1) = 6\pi\eta r V$$

$$V = \frac{2g(\rho - \rho_1)r^2}{9\eta} \quad \ldots\ldots (3)$$

In Stokes' experiments Equation 3 was used to determine the viscosity coefficient from the observed velocity of the falling sphere. It also can be used to estimate the rate of rise of the globule of oil when the diameter of the globule and the density of the oil of which the globule is composed are known, and when certain conditions are assured. These conditions are:

a. That the velocity of rise is sufficiently small that its higher powers may be ignored,
b. That there is no slip between the liquid and the surface of the sphere.
c. The liquid is extended indefinitely.

Rayleigh [160] developed a criterion which may be used to indicate when the velocity is not too large. He states that the velocity is small when:

$$\mathrm{R} = \frac{r\rho V}{\eta} < 1$$

Note: R = Reynolds' Number, which will be discussed later.

Arnold [161] introduced another method of approach; i.e., that of the critical radius. This he defines as follows:

$$\frac{r_c \rho V}{\eta} = 1, \text{ or } r_c = \frac{\eta}{\rho V} \quad \ldots\ldots (4)$$

After many experiments in which he employed spheres of various materials and globules of various liquids, he concluded that there is no deviation from Stokes' Law which exceeds the usual experimental error when:

$$r = < 0.6 r_c \quad \ldots\ldots (5)$$

in which, as well as in the equations above r_c = the critical radius, which cannot be exceeded.

The second condition can be taken as assured from numerous experiments.

The third condition cannot be satis-

fied experimetally, although in Ladenburg's[162] experiments it was shown clearly that there were both end wall and side wall effects. A study of Ladenburg's work, however, will show that for present purposes these effects can be ignored.

Stokes worked with metallic spheres which were undeformable, a condition which does not hold when oil globules are involved. Oil globules are deformable because flow takes place within the globule. Bond[163] worked out the evaluation of this effect mathematically as follows:

$$k=\frac{2/3+\eta_1/\eta}{1+\eta_1/\eta} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

in which:

η_1 = the viscosity of the liquid forming the globules,

η = the viscosity of the liquid in which the globules are suspended.

It should be noted that when η_1/η is very large, k is nearly 1.0, the condition of solid spheres, and when very small, k approaches 2/3.

The factor k usually is incorporated in the equation of Stokes as follows:

$$V=\frac{1}{k}\cdot\frac{2g(\rho-\rho_1)r^2}{9\eta} \quad \ldots\ldots\ldots\ldots (7)$$

The values of k determined mathematically were checked experimentally and found to be reliable.

The Equation 7 of Stokes' is the principal one for sedimentation as employed in the separation of oil from water. It now can be analyzed to see just what it indicates, for only when there is a good understanding of the laws governing a procedure can equipment for operating the procedure be designed intelligently.

The first factor which presents itself is $1/k$. What does it tell? It is known that when a globule of oil rises from any point in a body of water it starts in the shape of a perfect sphere, and it starts to travel a straight line path which is perpendicular to the surface of the water body. It may retain this shape and path or it may not, depending upon its viscosity, surface tension, and size.

At the point of origin, i.e., where the oil globule starts, a certain pressure will exist, and according to the fluid mechanics law will act equally in all directions. At the same time the globule of oil will start to rise because its weight is less than the weight of a quantity of water equal in volume. The path of rise is vertical, provided that the globule retains its spherical shape.

The spherical shape of the globule is a result of the surface tension and viscosity of the oil. But the globule is subject to the pressure mentioned above which acts in a vertical downward direction. The reaction to this pressure, i.e., that causing the globule to rise, is augmented by the effect of its upward velocity.

Thus the downward action, although less than the upward reaction, is greater than the lateral pressure on the globule. Unless the globule is so small that the pressure on its projected horizontal area is less than the resistance provided by the viscosity and surface tension of the oil, the globule will be flattened on the top. Otherwise it will remain globular and will continue to rise in a straight line.

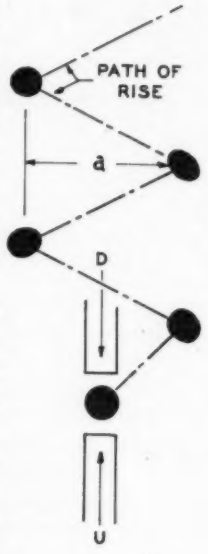

Fig. 1 — Diagram of the path of a large globule of oil moving upward through water when the forces of viscosity and surface tension are exceeded by external forces. In the drawing, D is the hydrostatic pressure on the projected area plus the weight of the globule (a minus value), U is the hydrostatic pressure on the projected area and a = amplitude of the path. D < U and > the forces of viscosity plus surface tension and globule is flattened. (Note: the distortion of the globule is exagerated in this drawing)

If the viscosity is not sufficient to resist distortion, and the globule becomes flattened, the flattened surface will offer increasingly greater resistance to rise and the globule will tend to move laterally. But again the buoyancy will influence this lateral motion and cause the globule to move in a zigzag path, as shown in Fig. 1. What may be called the amplitude of the zigzag path (i.e., "*a*" in Fig. 1) will depend partly upon the viscosity of the oil, and thus this characteristic becomes a pertinent factor in the type of sedimentation under discussion.

Whether the globule of oil will rise or not depends upon the force of buoyancy, and the buoyancy, as mentioned above, depends upon $\rho - \rho_1$ as in the Stokes equation, Equation 7. In Equation 7, ρ = the density of the substance in the sphere, and ρ_1 = the density of the medium, i.e., the water. Obviously, in the case of a globule of oil lighter than water, and water as a medium, $\rho - \rho_1$ will be a negative value. The minus sign has no other significance, however, than being an indication that the globule will rise. Further, since this factor is in the numerator of the equation, the greater the difference, the greater will be the buoyancy effect. The minus sign is ignored in calculation, since all values are positive. It will be apparent immediately that the buoyancy effect is of primary importance in sedimentation.

Of equal importance in sedimentation is the factor r, which is the symbol for the radius of the globule. Since this factor also is in the numerator of the equation, the larger the radius, the greater will be the velocity of rise.

The factor r is a second power factor. This means that a globule of oil which is twice the size of another globule will be four times as buoyant as the other, and when in undistorted globular form will rise four times as rapidly. This increased size also will increase the amplitude of the zigzag path of rise of large globules of oil through water for there will be greater projected area for resistance and greater velocity reaction when other conditions are equal.

The final factor in Equation 7 is the factor η, the viscosity coefficient or absolute viscosity of the medium (i.e. water). Since this factor is a part of the denominator in the equation, the greater its value, the lower will be the rate of rise of any particle, e.g., a globule of oil, through the medium. This will be understood readily when there is realization that in general viscosity approaches solidity as a limit, and there will be no rise through solid water, i.e., ice.

All the above factors pertain to sedimentation under conditions of quiescence, the conditions upon which practical applications of sedimentation in continuous operation are based. This must be made clear, for in its explanation lies understanding of the translation from quiescent, or batch operation, to continuous operation.

Assume that in a small refinery all wastes containing oil are transferred to one of a series of several tanks. When the tank becomes full, the flow of waste is transferred to the second tank in the series. The contents of the first tank meanwhile is settling under quiescent conditions. Any oil present in large globules quickly rises to the surface, oil in medium sized globules more slowly, and very small globules (e.g., 0.02 centimeters in diameter) quite slowly.

Gradually all free oil accumulates on the surface, leaving the water below practically oil free. While the last tank in the series is being filled, the oil is removed from the first tank and the water drawn off to disposal. Then a new cycle is started. These are ideal, quiescent sedimentation conditions which are to be provided, as nearly as possible, in any practical, continuously operating equipment for waste treatment.

In the series of tanks as above, the tanks are separate, individual, and probably round units. Now imagine these tanks, of the same capacity, to be rectangular in shape, and arranged in a row, so that the dividing walls are common. They are still to be operated in a cycle, however, and the same ideal conditions are maintained.

Finally, imagine that the common walls all are removed. The waste is introduced continuously into one end and oil-free water leaves the other. Then there will

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have come into existence the simplest form of what commonly is called the "gravity-type, oil-water separator," the equipment through which sedimentation is applied as a waste treatment procedure. There must be added certain accessories, however, and these will tend to break down the conditions which are ideal for sedimentation.

Consequently, the problems of separator design, which is the next step in the discussion of sedimentation, may be summarized as problems of introducing accessory equipment into a separator of adequate size so that ideal sedimentation conditions will be disturbed as little as possible. Sedimentation then will take place with the greatest effectiveness commensurate with practical application.

In the series of tanks first described, the only agitation of the tank content occurred when the tank was filling. After it was filled there was no agitation or flow, with the possible exception of thermal currents which will be considered later. But in the rectangular box there was flow from one end to the other.

Unless this flow is controlled so that it is not turbulent and is free of eddy currents or thermal currents, it will have a mixing rather than a separating effect upon the oily waste. Therefore, the first thought in the design of sedimentation equipment must be given to the matter of *flow rate* of the waste through the equipment, for proper rate of flow will contribute most to retaining ideal conditions.

The ideal flow is known as laminar or straight line flow, in which the velocity at any point in a vertical transverse section will be the same as the velocity at any other point in the same or any other similar section. Under such hydraulic conditions there will be no difference between batch (quiescent) and continuous separation. This is illustrated clearly in Fig. 2. But this perfect type of flow cannot be achieved because of the accessory equipment necessary to a practical, usable separator.

Knowing that there must be some interference with the ideal conditions, it will be necessary to design so that the effect of the interference will be minimized to the greatest degree possible. Any turbulence which results must be so small that the waste will flow around the various accessories without resultant eddies and vortices. In arriving at such a flow rate the velocity and other conditions of laminar flow must be established first for clear understanding.

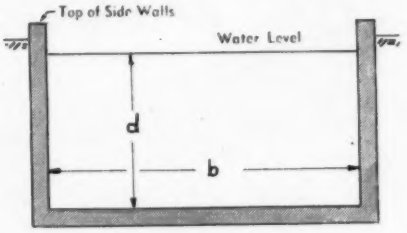

Fig. 3—Cross-section of a continuous sedimentation chamber. Area of flow = d × b. Wetted perimeter = d + b + d. Hydraulic radius = (d × b) ÷ (d + b + d) = Area ÷ Wetted perimeter

In establishing the dimensions and velocities for this basic, quiet flow, the separator may be regarded as an open channel with a reservoir at the head from which the waste flow is introduced. The shape of the channel cross-section for optimum conditions, and the allowable velocity of flow through it, must be established first.

At the transition point between straight line flow and turbulent flow there is a velocity known as the critical velocity. At any velocity below the critical, the flow will be straight line, or laminar. Above the critical the flow will be turbulent. Hopf[164] experimented with open channels and found that the critical velocity could be calculated:

$$v_c = \frac{360\nu}{R} \qquad (8)$$

in which:

v_c = the critical velocity in ft./sec.
ν = the kinematical viscosity of the water in sq. ft./sec.
R = the hydraulic radius.

Reynolds[165] also experimented with various types of flow and established the equation for the dimensionless value known as Reynolds' number:

$$R = \frac{VR}{\nu} \qquad (9)$$

in which:

V = the velocity in ft./sec.

It will be noticed that both these equations contain the terms ν and R. The kinematical viscosity, ν, in sq.m/sec. for water can be calculated as follows:

$$\nu = \frac{1.7756}{1+0.03368T+0.000221T^2} \times 10^{-6} \qquad (10)$$

in which:

T = the temperature of water in °C.

This is the formula of Poisseville.

R, the hydraulic radius, equals the areas of flow cross section divided by P, the wetted perimeter:

$$R = A/P$$

In order to know the wetted perimeter, the hydraulic cross section must be known, and also its dimensions. This is derived from the hydraulic radius also.

In Fig. 3 a rectangular cross section channel is shown. According to the formula for hydraulic radius:

$$R = A/(b+2d) \text{ and, } b = A/d$$

$$\text{then, } R = \frac{A}{\frac{A}{d}+2d} = \frac{Ad}{A+2d^2}$$

By differentiating with respect to d and equating to 0 it can be shown that $A = 2d^2$. Also, $A = bd$. Therefore $b = 2d$, or in other words, the breadth of the channel should be twice the depth.

It now becomes necessary to decide upon some standard dimension which will provide a piece of sedimentation equipment which will have general application and permit the use of standard accessory equipment. It cannot be of too great size, however, because of the possible interference with distribution. As a round number value for the width, 20 ft. has been found to be a very satisfactory figure. It will be discussed further later.

With this value as a basis the dimensions of the cross section can be figured. The depth will be half the breadth, or 10 ft., and the area of cross section 20 × 10 = 200 sq. ft. The hydraulic radius will be 200 ÷ (20 + 10 + 10) = 5.

In order to know the quantity of water which may be passed through the channel under theoretically proper conditions for effective sedimentation, the critical velocity must be known. This can be found by the Equations 8 and 10 already given.

$$v_c = \frac{360\nu}{R}$$

in which;

$$\nu = \frac{1.7756}{1+0.03368T+0.000221T^2} \times 10^{-6}$$

When a temperature of 30° C. is assumed, and the equations are solved,

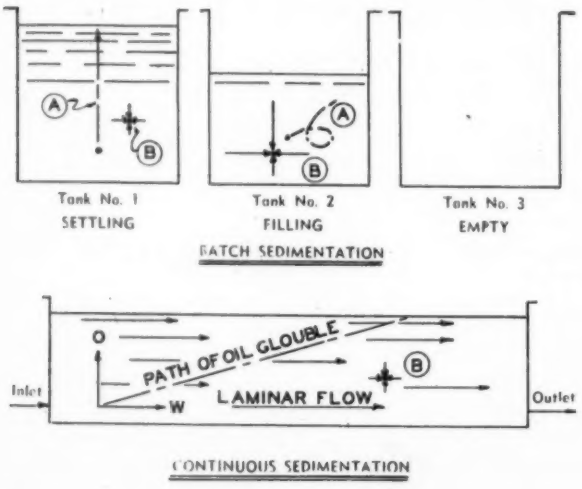

Fig. 2 — Comparison of batch or quiescent sedimentation with simple continuous sedimentation. A = path of oil globule. B = turbulence effects (in tank No. 1, zero; in tank No. 2, pronounced; in continuous flow tank, zero). O = velocity of rise of oil globule. W = velocity of flow through chamber

ν = 0.000000803 square meters/sec., equivalent to 0.0000086 sq. ft./sec. Then v_c, the critical velocity is 0.00062 ft./sec. The waste flow thus is determined as 60 × 0.00062 × 200 × 7.5 = 55.8 gpm.

Thus for theoretically perfect conditions of sedimentation, a 10 × 20 ft. cross section will have a capacity of only 55.8 gpm. In such a section any globule of oil which differs in density from the water in which it is moving will either rise to the surface or sink to the bottom, provided the section is sufficiently extended, and provided there is no interference by thermal or other currents.

The action of the globule will be the same as under quiescent conditions, but its path will be the vector of a rectangular longitudinal section. The comparison of the actions has been shown in Fig. 2.

Values Need Not Be Adhered to Strictly

The fundamental conditions just developed can be regarded as the basis for continuously operating separator design, but there are several reasons why the various values need not be adhered to strictly.

In the first place, the type of flow (i. e. laminar flow) is practically unattainable in plant size equipment. Thermal currents, eddy currents caused by structural conditions and even relatively smooth surfaces, surface currents, and wave action caused by winds, all would act to destroy the laminar flow.

Secondly, the allowable velocity through the section would require an impracticable width of sections. As an example, should a globule of oil require 11.4 minutes to rise through eight of the ten feet of depth, the section extension theoretically would be only 0.42 ft. in length, but for a waste flow of 7000 gallons per minute the required width would be 125 ft. For the flows of some large refineries the width would be 400 to 500 ft.

Under these conditions it would be difficult to design necessary accessory equipment which would not seriously interfere with proper flow without increasing the section extension by perhaps 100 times. Size of this order will not give commensurate return in effectiveness.

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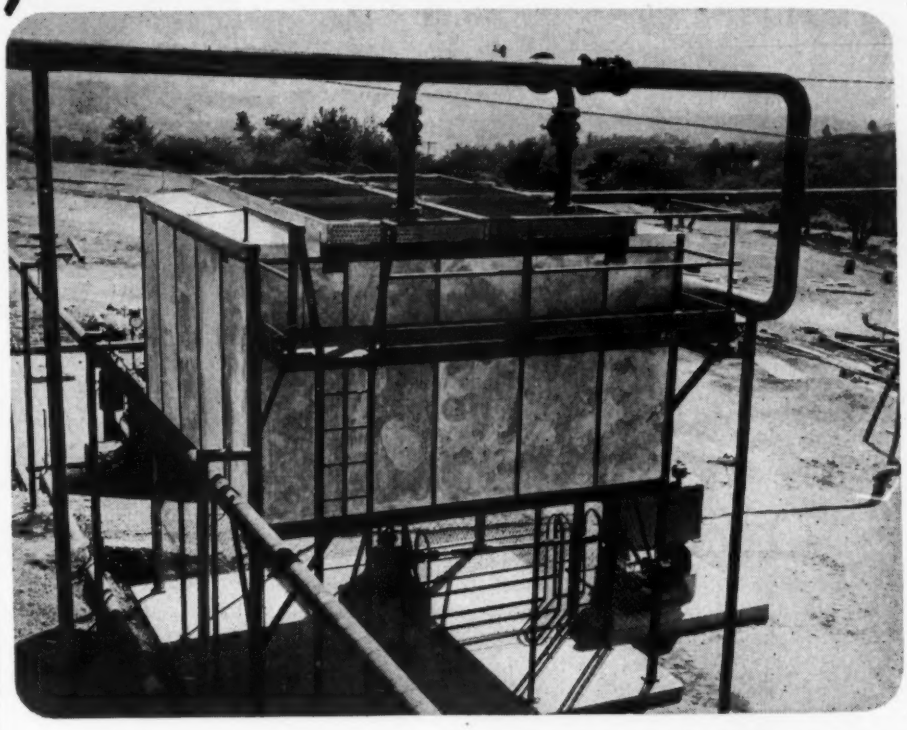

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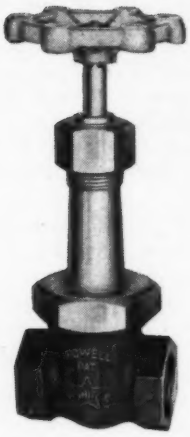

Fig. 375—200-pound Bronze Gate Valve with screwed ends, inside screw rising stem, union bonnet and renewable, wear-resisting "Powellium" nickel bronze disc.

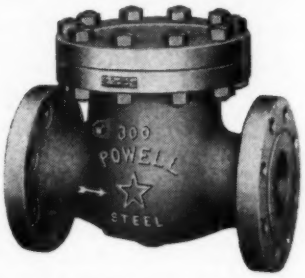

Fig. 3061—Class 300-pound Cast Steel Swing Check Valve. Flanged ends and bolted cap. Disc has ample lift to permit full, straight-way, unobstructed flow through the valve body.

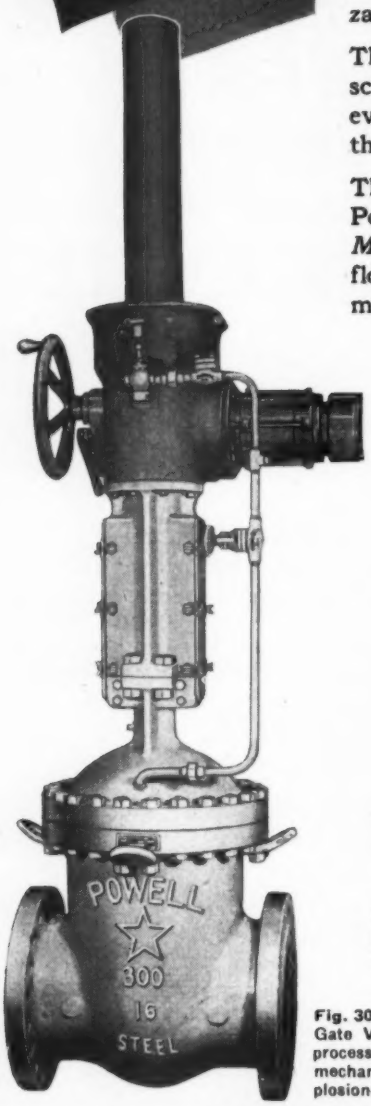

Fig. 3023—Class 300-pound 16" Cast Steel Gate Valve, designed especially for catalytic processing. Has automatic steam sealing mechanism and top-mounted, enclosed, explosion-proof, electric motor operator.

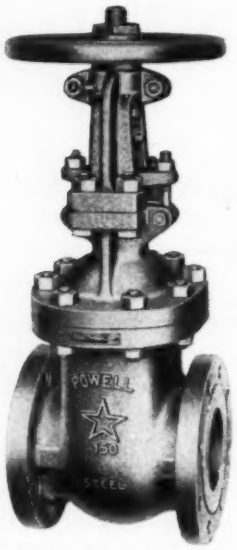

Fig. 1503—Class 150-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke, taper wedge solid disc.

Fig. 1793—125-pound Iron Body Bronze Mounted Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke, bronze seat rings and taper wedge solid disc. Also available in All Iron.

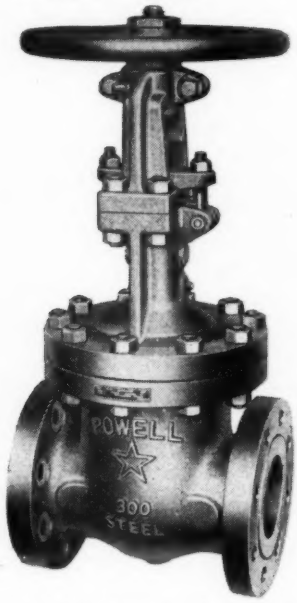

Fig. 3003—Class 300-pound Cast Steel Gate Valve with bolted flanged yoke, outside screw rising stem and taper wedge solid disc.

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Proper Operation and Maintenance Insures Full Advantages of Floating Roof Tanks

By FRED L. GOLDSBY and C. M. ORR

Development Engineers
Chicago Bridge & Iron Co.

Tips and suggestions are presented for obtaining maximum efficiency from floating roof type tanks for the storage of crudes and refined products. It is demonstrated that a knowledge of the design and construction of such tanks is essential to achieving long life and safe operation. Descriptions of the various accessories are also given.

Because a floating roof tank is a mechanical device, its advantages—elimination of fire hazards, reduction of evaporation losses and corrosion—are most economically maintained by inexpensive, regular inspection procedures. Important inspection items are drainage facilities, sealing rings, rim vents, manholes, and gages.

FLOATING roofs are used primarily to reduce evaporation loss, decrease corrosion, and eliminate fire hazard in tanks storing volatile liquids. To serve these purposes best, the user naturally desires to operate and maintain his floating roofs with a minimum of expense and effort.

From Figs. 1 and 2, it can readily be observed that a floating roof is a moving structure. As such, some operating care and maintenance is necessary in order to obtain maximum efficiency from the roof. To keep an automobile in smooth running condition it is necessary to have periodic inspections to check the condition of the motor, brakes, wheels, etc. These things are done as a matter of course. If not, the car soon ceases to operate properly and large repair bills are necessary.

Similarly, since a floating roof is a mechanical device, inexpensive, regular inspection of the roof and its accessories will insure continuous, safe operation and a longer life.

Thousands of floating roofs of all types and sizes are in service throughout the world. The owners of these roofs have acquired a wealth of practical operating experience which has set the standards for the design of the most modern floating roof. This construction and service experience have proved that regular inspections to insure maximum efficiency and longer life can be accomplished with a minimum maintenance cost.

Since product and service requirements account for variations in the type of floating roofs and their accessories it is, of course, necessary to limit any remarks regarding maintenance procedure in this article to generalities. Maintenance and operation instructions are usually furnished with each roof, giving specific directions for proper care of the roof and the accessories furnished therewith.

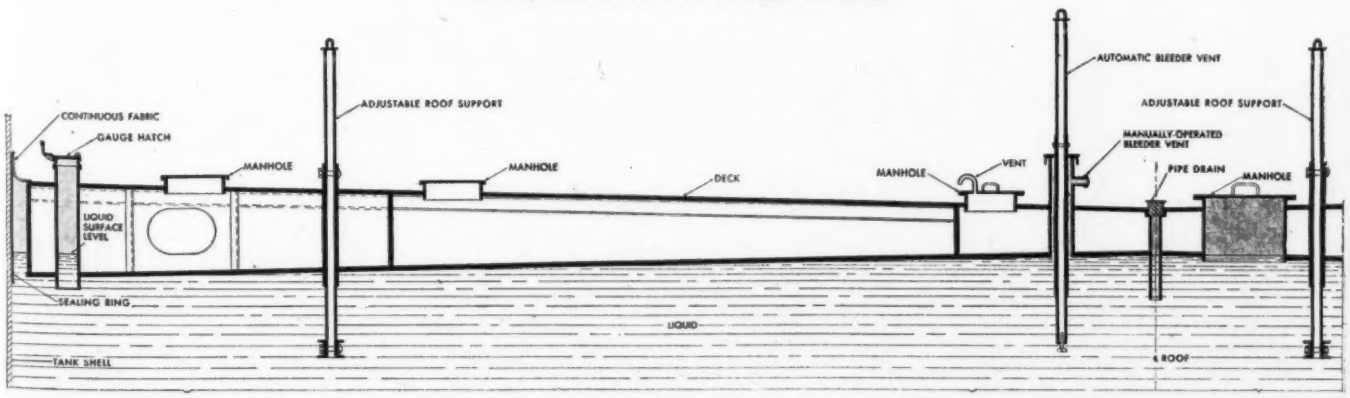
Fig. 1—Sectional view showing fittings normally furnished with a doubledeck floating roof, such as shown in Fig. 2. Roof shown is for a 70 ft. diameter tank

Inspection

The first, and probably most important, phase of good floating roof maintenance is to make some one individual responsible for inspecting all floating roofs and their fittings at regular intervals. By study of the maintenance and operating instructions and of the drawings provided with each roof, a thorough understanding of its operation can be obtained which, together with good judgment on the part of the inspector, will lead to the best care of the roof.

The seal of a floating roof has sufficient flexibility to allow for reasonable variations in tank diameter. If the tank is badly "out-of-round," however, the roof may bind at some points or the sealing ring may fail to contact the shell properly at others. Such conditions hamper the operation of the roof and should be corrected by leveling the tank grade to round the shell.

Floating roofs should be painted white, aluminum, or some other light-reflecting color. This will effect a reduction of several degrees in liquid surface temperature, thereby enabling the roof to operate at its maximum efficiency in preventing evaporation loss. Clean, unob-



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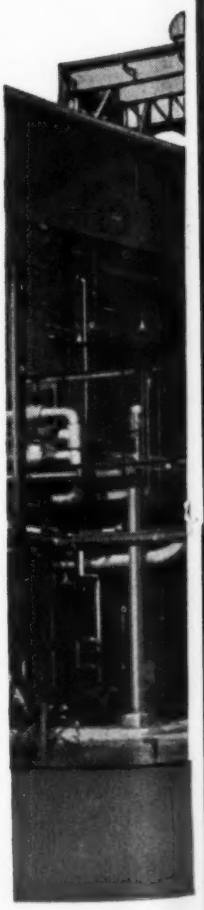

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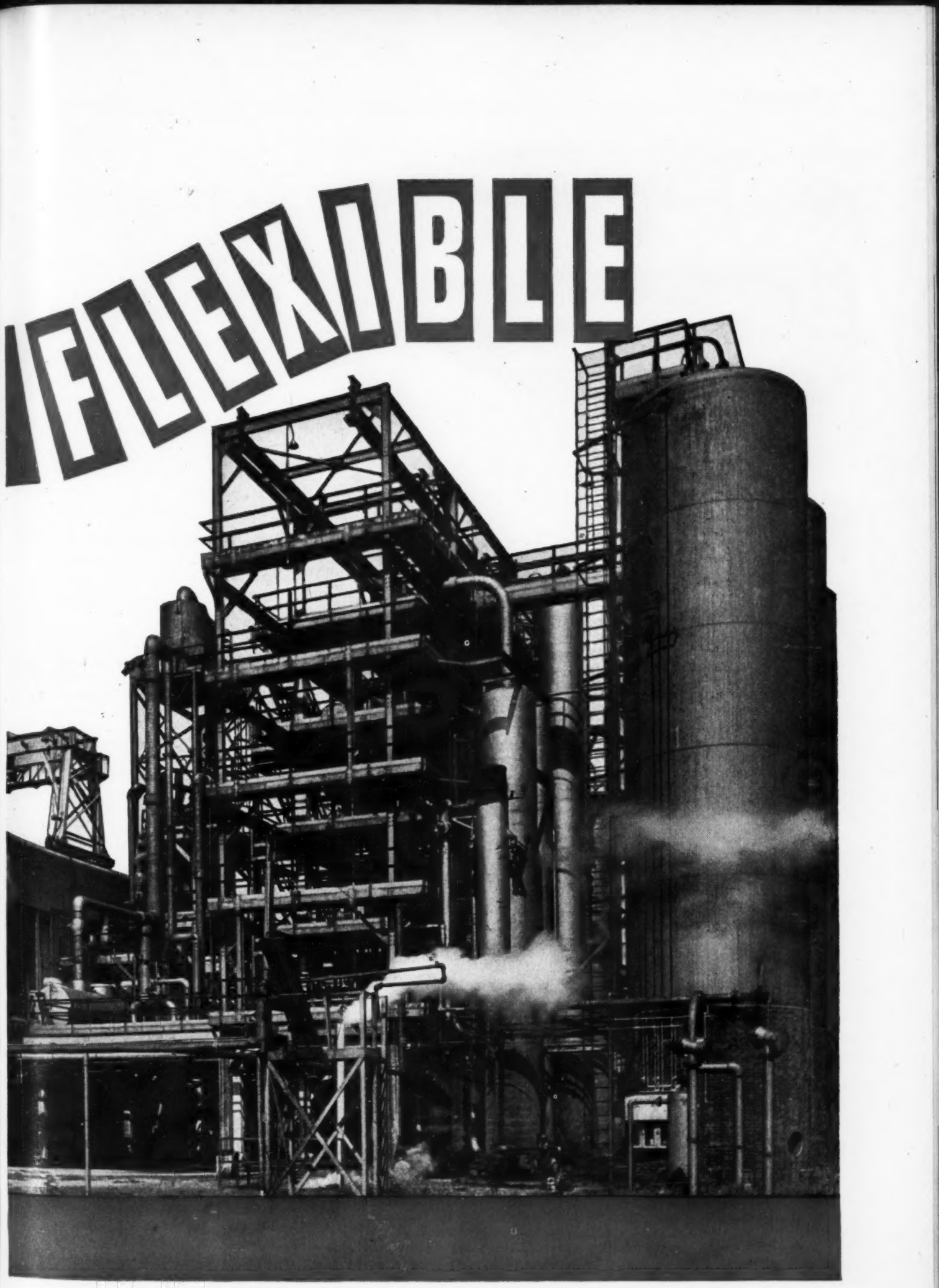
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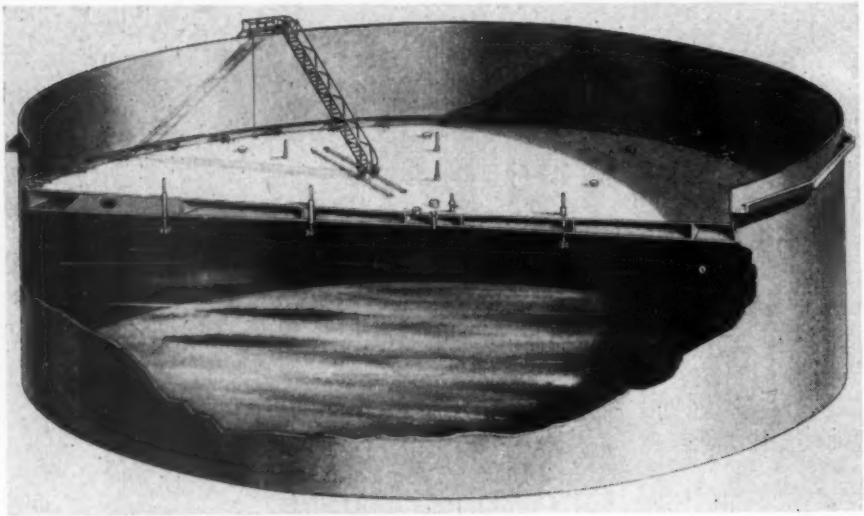

Fig. 2—Cutaway view of a typical Horton Double-Deck Floating Roof in a butt-welded tank, most often used in tanks from 80 to 100 ft. in diameter

structed decks on the newest design of roofs reduce cleaning and painting costs to a minimum.

Drainage

Since most tanks equipped with floating roofs have open tops, some means for removing rainwater from the deck must be provided. Depending on the type of service and style of roof, drains may be one of four types.

1. **Open Pipe Drain (Fig. 1).** This type of drain is usually furnished with double deck floating roofs in finished product service. It allows water to settle through the product to the tank bottom where it is withdrawn from the tank through the usual water drawoff connection. Since there are no moving parts the only attention it requires is an occasional check to make sure the screened opening has not become clogged with debris.

2. **Siphon Drain (Fig. 3):** On single deck roofs where the product level is higher than the deck when the roof is floating, open pipe drains must be equipped with water siphons to prevent product from flooding the deck. Once primed, a siphon drain operates automatically. Priming is accomplished by pouring water into the water pan.

Any water falling on the deck thereafter will flow through the siphon to the tank bottom. During periods in which the oil temperature may fall below 32° F. some types of siphon drain should be removed from service by inserting the plug pipe and removing the water from the drain to prevent damage due to freezing.

Water does not have to be removed from other so-called "freeze proof" siphon drains, but these become inoperative during periods when the water in them is frozen solid. This type should be checked periodically to make sure the water pan is not damaged by freezing.

Siphon drains should likewise be kept clean and free of debris.

3. **Swing Joint Pipe Drain (Fig. 4):** Floating roofs intended for crude oil service or for other types of service where a water bottom is objectionable, are usually provided with this type of drain. This drain removes water from the deck without allowing it to come in contact with the contents of the tank. With this type of drain open pipe emergency overflow drains are also provided.

The swing joint pipe drain should be inspected at regular intervals to make sure the sump is clean and the gate valve is in working order. The gate valve at the shell is normally closed but should be opened after each rain to drain water from the deck. This type drain should be freed of water and closed at both inlet and outlet when the temperature of the stored product is less than 32° F.

4. **Flexible Hose Drain (Fig. 5):** This type drain serves the same purpose and requires the same maintenance as the swing joint pipe drain except it is usually used only in warm climates where product temperatures seldom get below freezing. In case replacement of the hose is necessary it can be easily withdrawn through the shell connection and replaced without cleaning and gas-freeing the tank.

Seal

The seal is one of the most important parts of a floating roof. If it becomes damaged or fails to operate properly, the efficiency of the roof may be seriously reduced. To prevent this, the following steps should be taken.

Sealing Ring—Rain following a severe cold spell may cause the metal sealing ring to freeze to the tank shell. When such conditions exist, the sealing ring should be loosened before pumping product into or out of the tank.

If the fabric forming the flexible curtain should become torn or damaged, it should be repaired without delay.

Secondary seals, where used, should be replaced when worn out.

Miscellaneous Equipment

The rim vents should be inspected at regular intervals. Valve seats and bug screens should be kept clean.

When necessary on mercury sealed vents, the annular depression should be cleaned and refilled with mercury.

Automatic gauges should be inspected regularly to see that they operate smoothly. Sheave bearings and reading windows should be cleaned when necessary.

In order to facilitate inspection, each individual pontoon compartment is provided with a manhole having a loose flanged cover. This construction keeps water out of the pontoons but permits workmen to enter with a minimum of effort.

Taking Roof Out of Service

When the roof is to be supported in the high position for inspection or cleaning, the following precautions should be observed:

(1) On roofs equipped with an auto-

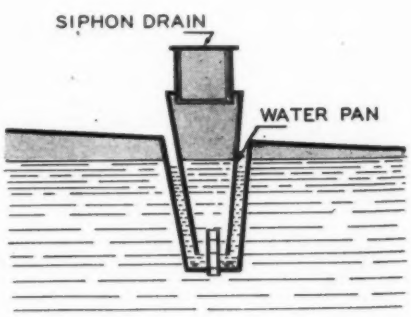

Fig. 3—Siphon drain, used on single deck roofs where the product level is higher than the deck when the roof is floating to prevent product from flooding the deck. Siphon is primed by pouring water into water pan

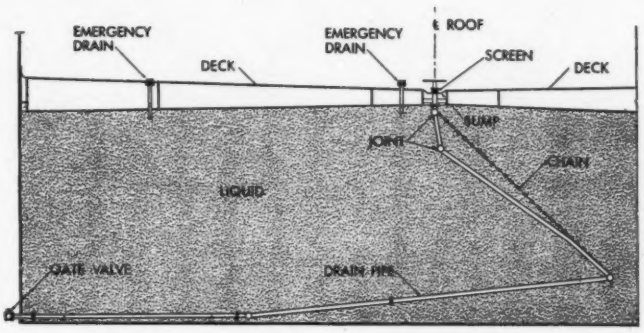

Fig. 4—Installation of swing-joint pipe drain and emergency drains

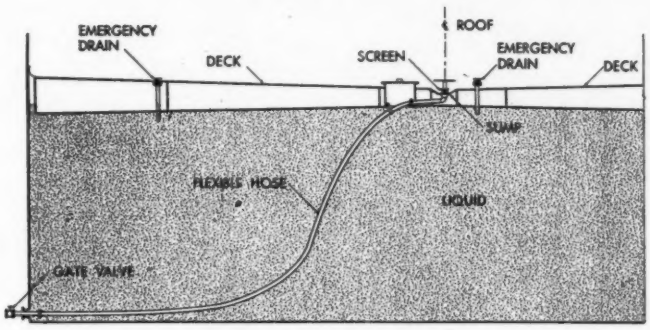

Fig. 5—Installation of flexible hose drain and emergency drains

matic bleeder vent, see that the operating pipe is adjusted to match the high position of the adjustable roof supports. If this is not done, the vent will not open when the roof comes to rest, and the load caused by the resultant vacuum may damage the roof or the pipe supports. As a further precaution, the manually operated bleeder vent should also be opened.

(2) If the roof is equipped with a flexible pipe or hose drain, remove riser of center emergency overflow to drain the deck.

(3) The roof should not be subjected to an ice or snow load in excess of the design loads used with the roof on high supports.

If greater loads are likely to accumulate, temporary blocking or shoring should be placed under the roof.

Putting Roof Back Into Service

When the roof is returned to service after an inactive period, the following should be done:

(1) Make sure that the metal sealing ring is not frozen to the tank shell.

(2) Be certain that neither the pipe supports nor the drainage system are embedded in ice in the tank bottom.

(3) After the roof is floating, readjust the length of the pipe supports and the automatic bleeder vent.

(4) Replace the center emergency overflow riser.

Gaging

Tanks equipped with floating roofs may be gaged with the same degree of accuracy as cone roof tanks provided the correct procedure is followed. It must be remembered that the roof displaces a volume of liquid equal in weight to the weight of the roof. Recommended gaging procedures are outlined below.

The procedure used in gaging the tank contents with a float gage is similar to that described below, the only difference being that the float gage reading is substituted for the reading obtained with a hand tape. A diagram of a typical float gage is shown in Fig. 6.

Gaging By Hand

When the roof is floating, proceed as follows:

(1) Using a standard gager's tape and plumb bob, measure the depth from the tank bottom to the liquid surface in the gage hatch. Read the corresponding volume from a gage table prepared exactly as though the tank had an ordinary cone roof. Then apply the necessary temperature correction to this volume.

(2) From the figure thus obtained, deduct a volume of oil equivalent to the floating weight of the roof plus any snow or water load that may be on it. The remainder is the true volume of oil in the tank. The floating weight of each roof is shown on a nameplate attached to the cover of one of the manholes.

As previously mentioned, the gage table for a tank equipped with a floating roof is prepared exactly as though the tank had a cone roof. The depths when the liquid first touches the under side of the roof and at which the roof is just floating should be indicated on the table. This will enable the gager to deduct a proportional part of the total roof displacement for gage readings between these points. If it is desired, greater accuracy in this range can be secured by introducing known quantities of liquid from another tank and tabulating the increase in volume for each inch of depth.

Refiners, tank farm operators, and all petroleum industry men concerned with the storage of crude oils and refined products will find they can obtain the best service from their floating roof tanks by a careful study of the above outline.

Just as regular inspection and maintenance is essential for plant operating equipment, pumps, motors, etc., so is it necessary for floating roofs because they are mechanical devices.

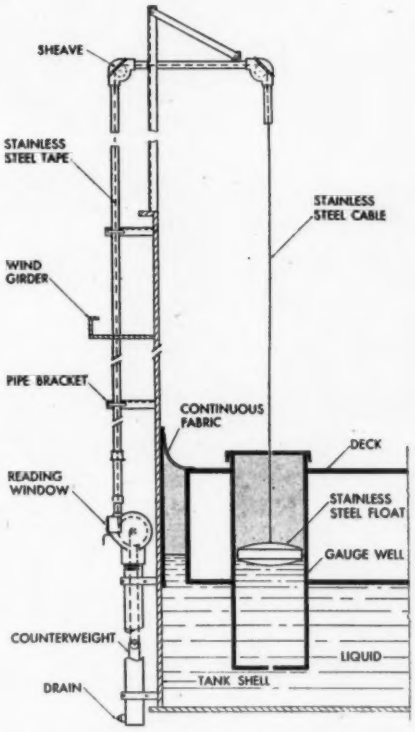

Fig. 6—Diagram of typical automatic float gage in a floating roof

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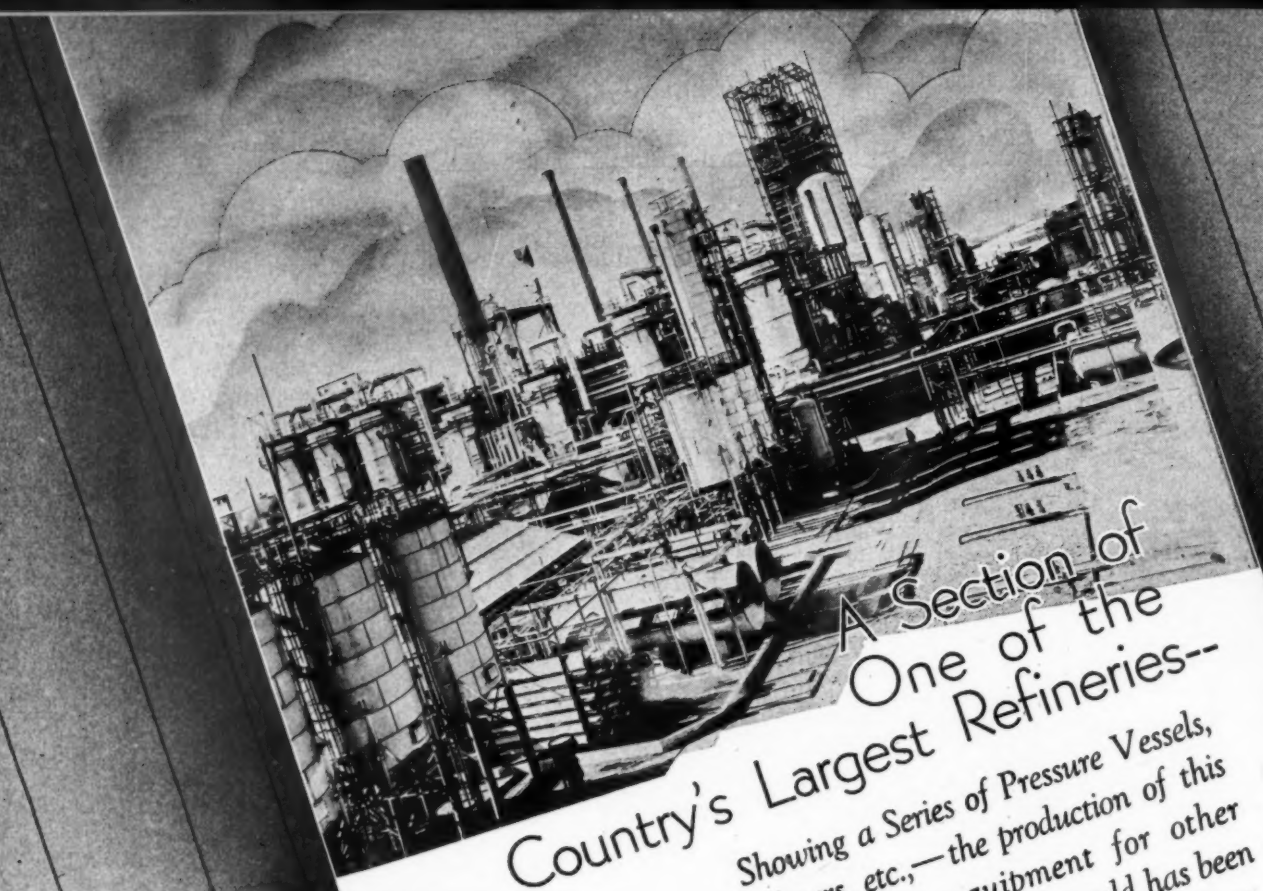

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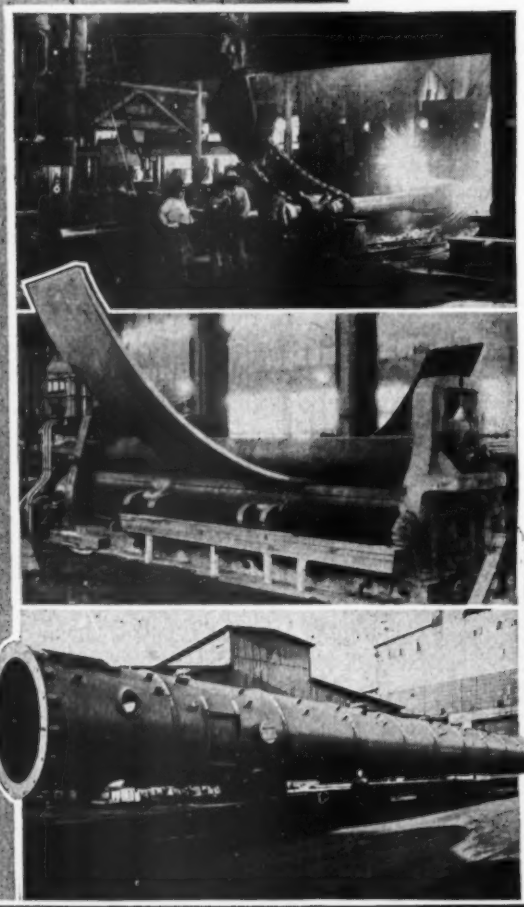

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Production of Synthetic Lubricating Oils By Hydrogenation Reactions

By GEORGE G. PRITZKER
Shell Development Co., San Francisco

Processes for the manufacture of synthetic lubricating oils have been known for nearly a century, but it has been only in recent years that much attention has been paid to their commercial use. Now, with specialized applications requiring lubricants with more stringent qualities, more and more attention is being directed to the field. The author reviews the development of the hydrogenation process for producing synthetic lubricants since Bergius first introduced his method in 1911. He describes various advances since then, and cites 37 literature and patent references.

SYNTHETIC lubricating production cannot be regarded as something new and novel, although new methods, processes, and treatment of new materials to produce lubricants are being continuously introduced. In fact, production of lubricants by synthetic means is almost as old as the oil industry itself.

Probably the first man to disclose that oil could be produced by synthetic means was Berthelot[1], who demonstrated in 1869 that a yield of 60% hydrocarbon oil can be obtained by treating coal with hydriodic acid solution at 270° C. However, very little work was done to develop processes for producing lubricants by synthetic means until Dr. Bergius in 1911 introduced and later developed a commercial method of producing synthetic lubricants by the hydrogenation process.

Started with Artificial Coal

The Bergius Hydrogenation process for producing synthetic lubricants originally started with the problem of forming artificial coal[2] from cellulose, peat, lignite, etc., by heating cellulose in an autoclave in the presence of water at temperatures of around 290-350° C. and up, to produce a product called "end kohle." Bergius observed that by treating "end kohle" with hydrogen under pressure and at a temperature of about 400° C., the product was converted into an oil. Later, Bergius discovered that by this process oil was produced whether natural or synthetic coal was used. The average yield obtained when starting out with approximately 100 kg. of coal was as follows: 20 kg. of oil having a boiling point of 230° C., 10 kg. of oil having a boiling point between 230-330° C., and 51 kg. of heavy oil and asphalt[3].

Iron Oxide is Catalyst

More specifically, the Bergius hydrogenation process[4] comprises crushing coal so that it passes a 2 mm. sieve and mixing the crushed coal with a heavy oil or tar in proportion of 2.5 to 1. The mixture is then subjected to a pressure of approximately 200 atms. and a temperature of 440-490° C., and hydrogen is introduced into the mixture. About 5% iron oxide was added to the mixture with the original idea of fixing the sulfur present in the coal, but it has since been shown that this material has a catalytic effect on the reaction.

In modern Bergius hydrogenation plants, the coal is first treated in a liquid phase and later portions of the product are hydrogenated in the vapor phase. For example, pulverized coal is mixed with heavy oil and a suitable catalyst and subjected to hydrogenation at 250 atms. and 400-480° C. A crude condensate is formed from the liquid phase which is distilled off and separated into fractions of spirit, middle oil, and heavy oil boiling over 300° C. The middle oil is vaporized, mixed with hydrogen, and passed over a catalytic bed at a temperature varying from 400-480° C. and 250 atms. pressure. The oil product formed has a boiling point above 200° C.

Early Work with Catalysts

The original Bergius hydrogenation process utilized few, if any, catalytic agents. In 1920-1921, the Badische Anilin und Soda Fabrik started to experiment with various catalytic agents with this process and eventually led to the I. G. Farbenindustrie A. G. hydrogenation process[5], which consisted essentially in breaking up coal in a mill and mixing it with heavy oil, to which a catalyst was added. The mixture was heated and hydrogenated under 300 atms. pressure and 400-460° C. At this temperature and pressure, the coal was split into particles and transformed into liquid high molecular weight hydrocarbons. This material, under the influence of high pressures and the catalyst, decomposes, and oil fractions are obtained upon further hydrogenation.

Standard Oil Enters Field

In 1926, Standard Oil became attracted to the I. G. Farbenindustrie Aktiengesellschaft work, and signed an agreement with I. G. for mutual development of the hydrogenation process for producing lubricating products. In 1929, an oil hydrogenation plant was built at Bayway, N. J., and two years later hydrogenated oil, under the name of "Essolube" oils, came on the market.

Essentially, the Bayway process[11] comprised hydrogenating oils in liquid phase at approximately 800° F. The oil and hydrogen mixture was preheated and the temperature then raised and the mixture passed through a packed catalyst at controlled temperature and pressure in order to obtain the desired end product.

The hydrogen used for this process was obtained from natural gas or refining gas, and the catalyst was one which was sulfur resistant[12]. It was observed that when the stock mixture was passed over the catalyst, the temperature rose to about 750-1000° F. or more.

Removes Most Impurities

Most impurities normally present in natural oils, such as sulfur, oxygen, and nitrogen, are eliminated from hydrogenated products. The elimination of these impurities is due in part to the catalyst used, which appears to be able to isolate these components during the hydrogenation process by transforming them into hydrogen sulfide, water, and ammonia. Another important function of the catalyst in hydrogenation processes is to reduce the temperature and pressure of a reaction[8]. Thus, with the use of suitable catalyst the pressure and temperature can be reduced from 1000 atms. and 500° C. to 200 atms. and 450° C. and still produce the same hydrogenation product.

In addition to the importance of select-

ing the proper catalysts to obtain the best oil yield, the type of material and the amount of hydrogen used must be carefully controlled, as well as the temperature and pressure of the reaction. Experience has shown that when heavy oils are hydrogenated, about 1% hydrogen should be used; whereas with liquid tar about 2% hydrogen should be used; with coke-oven tars about 3% hydrogen should be used, and with coal approximately 4 to 5% hydrogen should be used[9].

Polymerize Unsaturates

A French patent[10] assigned to I. G. Farbenindustrie A. G. discloses the hydrogenation of coal tar or mineral oil under pressure and in the presence of such catalysts as MoO_3, CrO_3, and kaolin to produce middle oils or benzine, which, in turn, were pressure hydrogenated to produce unsaturated hydrocarbons, and these unsaturates were polymerized to lubricating oil fractions.

Haslam and Bauer[11] obtained a lubricating oil by hydrogenation of an oil in the presence of a highly active sulfur resistant catalyst under 3000-4000 psi pressure. Nash[12] obtained a lubricating oil by hydrogenating coal and its distillates in the presence of aluminum chloride. The use of molybdenum, tungsten, and cobalt catalysts in the hydrogenation of poor lubricating oils at 300° C.[13] or 450° C.[14] in order to obtain high quality lubricating oils is disclosed in British patents.

Using the Bergius hydrogenation process, Spilker[15] noted that a synthetic lubricating oil can be obtained by hydrogenating solid aromatic hydrocarbons derived from coal tar. Nash[16] obtained synthetic lubricating oils from low temperature tars derived from the carbonization of brown coals and channels after the tar acids, bases, and waxes have been removed. Also, a patent granted to Haslam[17] discloses that a lubricating oil can be produced from coal or other solid carbonaceous materials by the action of hydrogen at pressures of 20-200 atms. and 600-800° F. According to Pier, a 20% yield of lubricating oil can be secured from the heavy oil obtained from the hydrogenation of brown coal.

Cobalt or Chromium Oxide Useful

Hydrogenation is also used in the treatment of oils to remove sulfur impurities and can be carried out in the presence of metallic sulfides,[18] such as nickel and molybdenum, at 100-300° C., with the aid of such activators as cobalt or chromium oxide.

Clark [19] produced lubricating oils from heavy unrefined hydrocarbons through the action of hydrogen at elevated temperatures of 700-850° F. and pressures of 20 to 200 atms. in the presence of a sulfur-insensitive catalyst, such as metallic oxides or sulfides of chromium, molybdenum, tungsten, and the like. Haslam[20] produced lubricating oils by hydrogenating heavy crudes at 830° F. under high pressures and in the presence of catalysts which comprise oxides and sulfides of elements of the sixth group of the periodic table or their mixtures, with zinc oxide, magnesium, lime, or aluminum.

Semmes[21] obtained lubricating oils from crude oil, reduced crudes, or heavy distillates by suspending these materials in a catalyst such as metals or oxides of metals of copper, zinc, nickel, cobalt, or iron, and forcing hydrogen at elevated temperatures of 700-870° F. through the reaction zone at a controlled rate and at pressures in excess of 50 atms.

In order to obtain lubricating fractions from crude oils, Jennings[22] heated a crude oil rapidly to an elevated temperature of 700-850° F. and then forced the crude into a reactor under pressures of 100-200 atms. or higher, where hydrogen is introduced. The reaction is carried out in the presence of metallic oxides or sulfides, etc. The gases and light oils are removed and the residue material is fractionated to desired lubricating oil fractions. The use of chromium and molybdenum oxide as catalytic agents in the hydrogenation of crudes at elevated temperature and pressure to produce lubricating fractions is disclosed in the Young patent.[23]

Other Catalysts Found

Pier,[24] in order to obtain lubricating products, hydrogenated distillates from carbonaceous materials such as coal, tars, mineral oil, etc., in the presence of such catalysts as alkali or alkaline earth metals with other element such as zinc and magnesium. These catalysts may be employed on carriers such as active carbon, silica gel, etc., and the entire reaction carried out under elevated temperature and pressure. Pier[25] also obtained lubricating oils from coal, shale, and other bituminous solid carbonaceous materials by treating them with organic solvents such as benzene and subjecting the extract to a treatment with reducing gases under controlled conditions of temperature and pressure. The preferred reducing gases were hydrogen and mixtures of carbon monoxide and hydrogen. The reaction was carried out at 200-430° C. under 50-1000 atms. pressure of molybdenum zinc catalyst.

Russel [26] discloses that in order to produce lubricating oil fractions from crudes by hydrogenation at elevated temperature and pressure in the presence of a catalyst, the crude should first be purified. Gounory[27] states that a more desirable product is obtained by using an excess of hydrogen when subjecting a crude to hydrogenation at 500-800° F. and pressures of 500-3000 lbs. in order to produce lubricating oils.

Coal Not Satisfactory

Studies made on producing lubricating oil from coal disclose that rehydrogenation of an oil obtained from the hydrogenation of coal did not produce a satisfactory lubricating oil. Condensation of the oil with ethylene in the presence of molybdic oxide catalysts supported on alumina gel, as well as other catalysts, such as ammonia, phospho-molybdate, phosphomolybdic acid, and activated alumina to produce lubricating oil, was also attempted.

The process of hydrogenating tar[28] containing asphalt in order to produce a lubricating oil is known. Before hydrogenating the tar, the asphalt is removed and the reaction is carried out at 400-485° C. and 50 atms. pressure in the presence of such catalysts as the halides of sulfur, selenium, tellurium, boron, phosphorus, or compounds capable of splitting of halides, such as CCl_4, $C_2H_4Cl_2$, NH_4Cl, etc.

Pressure hydrogenation of such substances as brown-coal tar, low temperature tar, and slate oil containing asphalt is disclosed in a French patent.[29] The process comprises hydrogenating these materials at 270° C. and 50 atms. pressure and then rehydrogenating at an elevated temperature in the presence of molybdic acid, zinc oxide, and magnesium oxide preheated with hydrogen sulfide to obtain lubricating oil.

Youker[30] produced lubricants by passing heated hydrogen and hydrogen gases at 210-800° F. through a mixture of sodium and heavy hydrocarbon liquid under superatmospheric pressure of 50-

Mr. Pritzker

The Author

George G. Pritzker, author of the accompanying article on hydrogenation processes for producing synthetic lubricating oils, spent nearly four years in the U. S. Patent Office examining patent applications on various lubricating compositions and lubricant additives, which has provided him with excellent background material for his surveys of patent literature.

A chemical engineering graduate of Brooklyn Polytechnic Institute, Mr. Pritzker left the Patent Office in 1946 to become associated with Shell Development Co. He is a member of the Patent Department of Shell's Petroleum Technology Division.

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250 atms. and preferably 200 atms.

Clarke[31] produced synthetic lubricating oil by hydrogenating condensed products of alkyl halide with an aromatic hydrocarbon. The alkyl halides used in the reaction were ethylene choride or propylene chloride or their dihalides, while the aromatics employed were toluene, mesitylene, tertiary butyl benzene, tertiary amyl benzene, *n*-butyl benzene, secondary butyl benzene, chlorobenzene, etc. The reaction was carried out in the presence of such catalysts as anhydrous halides Al, Fe, B, Mn, Ni, Zn, Sb, Cd, Sn, etc.

Boultbee[32] produced lubricating oils by dehydrogenating a nephthenic oil catalytically under such conditions as to dehydrogenate the naphthenes only, converting them to aromatic hydrocarbons and leaving the aliphatic hydrocarbons intact. These hydrocarbons are separated from the rest of the material and the remaining oil subjected to cracking to form olefins. The olefins so produced are polymerized to lubricating oil fractions. The reaction temperature usually varies between 200-500° F., and the dehydrogenating catalysts are metals such as Ag, Cu, Fe, Ni, Co, Al, or alloys and sulfides or oxides of Fe, Ni, Co, Zn, Cd, Al, Pb, Bi, Sn, Va, etc.

Olefins Polymerized

Lyman[33] produced synthetic lubricating oil by hydrogenating polymerized olefins or mixtures of olefins. Polymerization was carried out at atmospheric temperatures and pressures or at superatmospheric temperatures and pressures with suitable catalysts such as aluminum chloride, boron fluoride, ferric chloride, and anhydrous zinc chloride. These catalysts can be suspended in a carrier such as petroleum ether. The hydrogen step was carried out at superatmospheric temperatures and pressures such as 100-500° F. and 10-50 atms. in the presence of nickel, platinum, or palladium catalysts. Holm,[34] in order to produce a lubricant, polymerized sulfur-free water-free low boiling olefins with anhydrous aluminum chloride at 0-80° F. The low boling hydrocarbons formed were removed and the polymerized product subjected to saturation by hydrogenation at superatmospheric temperature and pressure in the presence of a nickel catalyst.

Lubricants were also obtained by Ellis by hydrogenating fatty oils, such as fish, whale, cotton, corn, linseed, rape, and tung oils.[35] Ellis also obtained a lubricant by hydrogenating an oil and graphite.[36] By hydrogenating soya bean oil and mixing it with 14% mineral oil, Fox[37] obtained an excellent lubricating composition.

Hydrogenated oil products, in addition to having the properties enumerated above, are characterized by their high VI and high flash points. They give excellent performance in various engines and machines under the most severe and adverse lubricating conditions. Above all, this process provides materials for lubricating purposes which by themselves are entirely unsuited for lubricating. In addition, in many hydrogenation processes by-products such as refinery gases and waste materials are processed and combined to produce lubricants.

Germans Relied on Hydrogenation

Germany relied heavily upon the hydrogenation processes for the production of synthetic lubricants during the war. Opinion among technical men examining German synthetic oil plants varies as to whether the Germans have really made any startling improvements or developments in the production of synthetic lubricants by the hydrogenation method.

Studies disclose that both the liquid and vapor phase stages during hydrogenation were used at a pressure of 700 atms. Operation at this pressure did not appear to increase the yields but reduced in some cases certain difficulties of operation. At the Boltrop vapor phase hydrogenation plant, a Ni-Zn catalyst was used at 700 atms. Attempts to hydrogenate a coal paste in oil at 140 to 148 atms. by the Pott-Broche process at Boltrop-Welheim proved unsatisfactory because the dissolved coal paste in the oil could not be hydrogenated.

Some novel hydrogenation equipment has been observed, but generally it is felt that nothing really spectacular has been achieved and that some of the German technical developments, particularly in oil production, seem to be rather amateurish.

Previous Articles

Other articles by Mr. Pritzker on the manufacture of synthetic lubricants and the use of additives in lubricants have been published in earlier issues of PETROLEUM PROCESSING and its predecessor, the *Technical Section* of NATIONAL PETROLEUM NEWS, as follows:

"Production of Synthetic Lubricating Oil by Condensation and Polymerization," NPN *Technical Section*, Aug. 7, 1946, pg. R-606 (part one), and PETROLEUM PROCESSING, Sept., 1946, pg. 58 (part two).

"Sulfonic Derivatives as Lubricating Additives?" NPN *Technical Section*, Oct. 3, 1945, pg. R-793.

"Sulfur and Sulfur Chloride Organic Reaction Products as 'Lube' Oil Additives," NPN *Technical Section* Nov. 7, 1945, pg. R-871.

"Use of Phosphorus Sulfide Organic Reaction Products as 'Lube' Oil Additives," NPN *Technical Section*, Dec. 5, 1945, pg. R-1001.

Next Month's Article

Synthetic Lubes By Voltolization

This process for subjecting oils or hydrocarbons to electric discharges to produce oils having superior lubricating qualities was developed commercially by a Belgian and was exploited by the Germans in the first World War. Much work has been done since in several countries on voltolization processes, a review of patents discloses.

This method for producing synthetic lubricants and properties of the oils is described in Mr. Pritzker's article to appear in the April PETROLEUM PROCESSING.

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Color Code for Piping Identifications Aids in Training Refinery Operators

By WILLIAM C. UHL
Staff Writer
PETROLEUM PROCESSING

Color helps refinery operators to learn piping arrangements quickly, aids maintenance department in repair work, and is essential in case of emergencies, engineers state.

Standard Oil Co. (Indiana), in completely color coding all lines in its new Whiting Fluid catalytic cracking unit. Atlantic Refining Co. and Standard Oil Co. of New Jersey, with modified schemes, have established the merits of a piping identification system.

Although only a few companies have as yet used color for piping, many have adopted it as a means for reducing accidents through various colored warning signs and symbols.

THE use of color coding in the modern oil refinery is valuable in teaching operators quickly and easily the "geography" or plot plan arrangement of the various piping systems.

In addition, pipeline color coding is a "string on the finger" reminder in the selection of the correct valve, especially in an emergency, when the quick recognition of the contents of a piping system is of paramount importance. It has also been of material assistance to maintenance personnel in reconditioning and repair work.

These advantages of piping system color codes have been definitely established by Standard Oil Co. (Indiana) in the complete color painting of all lines in the new Fluid catalytic cracking units at the Whiting refinery, as well as of other lines throughout the plant.

Atlantic Refining Co. and Standard Oil Co. of New Jersey both use color coding on refinery pipelines. However, their systems cover only the more important or the more hazardous materials.

Processing Grows Complex

Because of the continued growth in complexity of petroleum processing techniques and plants, the Indiana company adopted, as early as 1938, the policy of color coding lines. Experience since that time has substantiated the belief that this procedure would greatly assist refinery operators in obtaining a simplified picture of a complex unit.

Actually the first use of a planned and designed color at Whiting goes back about 25 years, when yellow was designated as the color to paint the pipelines supplying high pressure water for fire protection, replacing the original red. This was done because yellow surfaces have a much higher coefficient of reflection under white light than red surface do and therefore can be more readily recognized even under the poorest conditions of illumination.

Choice Is Arbitrary

The choice of the remaining color scheme has been more or less arbitrary, Indiana Standard engineers point out. The Whiting refinery is located on the southern shore of Lake Michigan, from which water for process cooling is obtained. This lake has a distinctly greenish hue, hence green was selected as the color designating lines handling cooling water.

Blue was arbitrarily chosen as the color for steam line systems. For many years black paint had been employed on oil lines, and was therefore retained. Brown was assigned to the pumpout system, and aluminum to instrument air lines.

In general, shades of the same color were avoided. The one exception is the use of light green for hot water and dark green for cold water lines. Stencilling is employed to distinguish between line systems of the same color but of different services.

All units constructed since 1938 have been color coded. It has been necessary to expand the original color scheme, but this has been easily accomplished by employing colored bands. For example, lines handling phenol in the Toluene Extraction Plant are painted white with red bands. At the Sulfuric Acid Alkylation Plant, the acid lines are painted white with black bands.

Still further expansion was required for the Fluid catalytic cracking unit recently placed in operation. A color chart for the line system in this unit is shown in Table 1. This cracking unit identification code uses complete painting of lines in primary colors, bands of color and stencilling in various combinations in order to accomplish its purpose. Although a total of 48 different types of services and their corresponding lines are covered by the cat cracker color code, the scheme is systematic and therefore easily learned.

In order to make them conspicuous, the instrument air lines are aluminum and the fire water lines are yellow. This was done because these two services are of primary importance to the continued safe operation of the unit.

Indiana Standard is one of the first oil companies to work out and use a *complete* color code for pipe line identification in a refinery. The use of color as a refinery tool is a relatively new technique, although many concerns have for years used color to identify products lines in marketing operations.

Atlantic Refining Also Uses Color

Atlantic Refining Co. has adopted to some extent an identification code for lines and valves in its processing units. The Atlantic system is as follows:

Service	Color
Air	Green
Acid	Black & Yellow stripes
Water	Blue
Lube and Gland oil to pumps	Yellow
Gas lines to gas-fired compressors	Orange

The balance of the unit and product lines are painted either aluminum or dark red, depending on location and service.

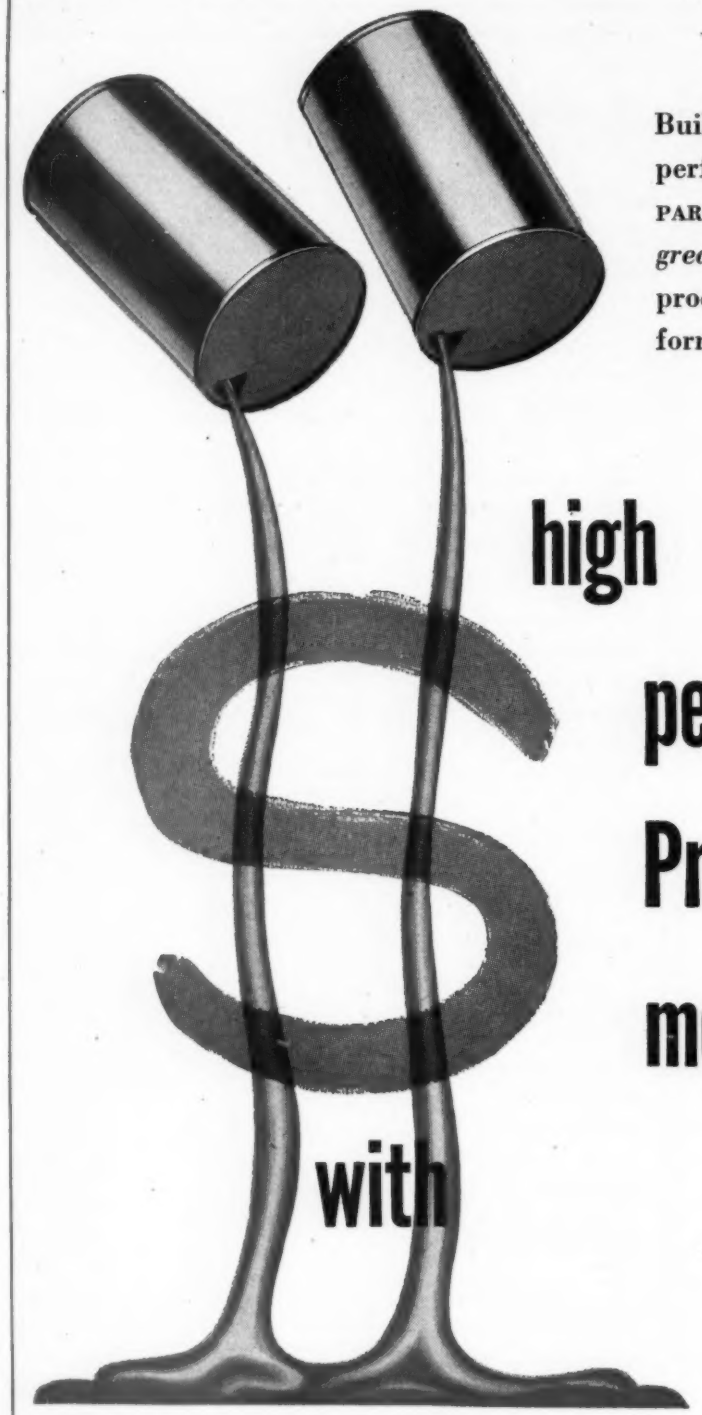
Like Standard of Indiana, Atlantic has found that using color identification on operating equipment has helped train personnel in better operating procedure and has lessened the time necessary for the training. It has also established good flexibility in the operating group. It is relatively simple to transfer a man from one unit to another if identification

TABLE 1–Color Identification Code for Refinery Piping

As Used in the New Whiting Fluid Catalytic Cracking Unit by Standard Oil Co. (Indiana), this Code Consists of a Primary Color Supplemented by Various Colored Bands and Stencilling

SERVICE	COLOR Primary	COLOR Bands	Stencil
OIL	Black	—	—
FUEL OIL	Black	—	FO
TORCH OIL	Black	Red	—
HYDRAULIC OIL	Black	Blue	—
GLAND OIL	Black	Lt. Green	—
GLAND OIL RETURN	Black	Lt. Green	GOR
FLUSHING OIL	Black	White	—
CLEANING OIL	Black	White	CO
MED. PRESSURE FLUSH OIL	Black	Orange	—
WARMING OIL	Black	Orange	WO
LOW PRESSURE FLUSH OIL	Black	Tank Grey	—
WATER DRAWOFF	Black	Dk. Green	—
DRAIN (from B-2)	Black	—	Drain
HOT PRESSURE DRAIN	Black	—	HPD
COLD PRESSURE DRAIN	Black	—	CPD
WET GAS	Red	—	WG
LOW PRESSURE FUEL GAS	Red	—	—
HIGH PRESSURE FUEL GAS	Red	Tank Grey	—
AERATION GAS	Red	Tank Grey	G
BLEED GAS	Red	Tank Grey	BG
INSTRUMENT AIR	Aluminum	—	—
PLANT AIR	Buff	—	—
MED. PRESSURE AIR	Buff	Black	—
BLEED AIR	Buff	Black	BA

SERVICE	COLOR Primary	COLOR Bands	Stencil
LOW PRESSURE AIR	Buff	Lt. Green	—
VACUUM EXHAUST STEAM	Blue	—	VE
10 LB. STEAM	Blue	—	E
100 LB. STEAM	Blue	—	—
MAKE STEAM	Blue	—	MS
400 LB. STEAM	Blue	Red	—
FIRE AND SNUFFING STEAM	Blue	Yellow	—
SUPERHEATED STEAM	Blue	Aluminum	—
COOLING WATER	Dk. Green	—	—
SERVICE WATER	Dk. Green	—	SW
COOLING WATER RETURN	Lt. Green	—	—
TREATED WATER	Lt. Green	—	TW
HOT WATER	Lt. Green	—	HW
BOILER FEED WATER	Lt. Green	—	BF
STEAM CONDENSATE	Lt. Green	—	SC
BLOWOFF (to B. D. Stack)	Lt. Green	—	BO
FIRE WATER	Yellow	—	—
CATALYST-AIR	Tank Grey	—	—
CATALYST VENT	Tank Grey	—	CV
PUMPOUT	Brown	—	—
SLURRY DRAIN	Brown	Black	—
LIGHT PRESSURE OIL	Brown	—	LPO
BLOWDOWN	Dk. Grey	—	—
RELIEF VENT	Dk. Grey	—	RV



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of lines and valves is the same, even though the operation of the unit may differ to some degree. They have also found the color code expedites an employe's action in case of an emergency through minimizing the possibility of turning the wrong valve.

Atlantic intends to extend its color identification system as much as possible in future installations, because past experience has proved the effectiveness of the project, minimizing and eliminating a great many emergencies.

Jersey Standard's System

Another company employing color to some extent in refineries is Standard Oil Co. of New Jersey. The principal lines and fittings using colors are fire hydrants (red), foam hydrants (yellow), chlorine lines (orange), and salt water in unit or battery limits (dark blue). Emergency pumper connections for fire protection are identified by yellow and red "barber-pole" stripes. Live and exhaust steam lines inside pumphouses are painted two different shades of gray.

In one Jersey Standard refinery, color is used in a unique way as part of the preventive maintenance program. Electric motors are painted a distinguishing color to show that they have been overhauled within the specified preventive maintenance period, which may vary from one to two years depending on service and location. This procedure provides an additional check on the performance record of each motor.

Find Some Colors Fail

Some years ago, Jersey Standard made an attempt to identify all pipelines, product, chemicals, and utilities, with distinguishing colors, and at one time as many as 14 colors were in use. The procedure was abandoned, however, because of the poor durability of certain paints under refinery atmospheric conditions, particularly where sour crudes were processed. Fading, spalling and cracking occurred in a relatively short time, rendering identification by this means worthless.

Because of the excellent service obtained, the use of aluminum paint was continued for most service and product lines without regard to location. At points of concentration of lines such as docks, pumphouses, and unit manifolds, enamel signs or lettering on the lines is provided to identify the material.

Color coding of lines in refineries is not only practical, but operating, maintenance, and safety departments will find in the near future that it is a necessity for efficient and safe operation, according to Roy G. Benson, a Chicago consulting safety engineer, and for 17 years safety engineer with Universal Oil Products Co.

"In order to make a color code work, there are a number of difficulties to overcome," he points out. They are:

"1. The prejudices of some of the old-timers in the industry to making their plants look like Christmas trees.

"2. A thorough study of corrosion-resistant paints so that a program, once started, will not fail because color does not hold up.

"3. A flow chart analysis of the problem with engineering, operating, and maintenance departments in full accord.

"4. Analysis of an erected unit and its relationship to other units.

"5. Complete education and re-education of personnel to the color code program.

"6. Identification signs placed throughout the area as a constant reminder of the materials covered by the various colors."

The objection to the time needed for a painting job can be easily overcome, Mr. Benson says. In one plant, a moderate sized paint crew completed a color coding job on a unit in less than 48 hours, working in shifts.

Color Also Used For Hazards

A large number of oil companies have used color to advantage as a warning of safety hazards in the refinery. The American Standards Association Safety Color Code is employed as is, or in some modified forms, by Continental Oil Co., Standard Oil Co. (Ohio), The Pure Oil Co., Atlantic Refining Co., Ashland Oil & Refining Co., Ohio Oil Co., Standard Oil Co. (Indiana), Standard Oil Co. (N. J.), and Standard Oil Co. of California.

The code, No. Z53.1-1945, was adopted by the Association in July, 1945. It uses only five colors. Red is designated as the basic color for fire protection equipment, danger, and stop. Yellow is the basic color for designating caution and for marking physical hazards. Solid yellow, yellow and black stripes or checkers, or yellow with a suitable contrasting background are used interchangeably.

Yellow for Trucks

Examples for the use of yellow would be electric trucks, bulldozers, corner markers for storage piles, guards for guy wires, unguarded edges of platforms, pits and wells, pillars and posts, top and bottom treads of stairways, lower pulley blocks on cranes, any projections, low beams, and the like.

Safety and first aid equipment is designated by green, or combinations of green and white. Housekeeping and traffic markings involve the use of black and white in stripes or checkers.

A comparatively new use for color is in connection with the construction of scaffolding. For perfect safety, floor planks in wooden scaffolds must be made of knot-free wood. To expedite quick erection of safe scaffolds, common practice of many refinery carpenter departments is to maintain an adequate stockpile of the proper type floor planking.

The safety rule at one refinery is to paint the ends of floor boards a brilliant orange. It is then relatively simple for a foreman or a safety engineer to spot an improperly built scaffold.

Color Can Be Safety Tool Also

Maintenance and repair shops can often use color to advantage as an aid to illumination and as a safety tool around moving machinery such as lathes, drill presses, pipe threaders, and bench grinders. For example, the new machine shop in the El Segundo refinery of Standard Oil Co. of California was completely analyzed and treated according to the prescription of "color doctors."

Soft grays and creamy yellows are found on the walls and ceiling. They minimize eye strain and provide an atmosphere that is psychologically pleasant. Points of operation on machine tools are painted in light creams and ivories in strong contrast to soft dark greens on the stationary parts, thus focussing the operator's attention exactly where it should be. Operating controls are colored a bright orange as an "attention-getter."

Color Definitely Needed

Beside the American Standards Association; the National Safety Council, the National Fire Protection Association, and many others have adopted recommended practices and codes for the use of color. The American Petroleum Institute has as yet done relatively little about the problem. According to David V. Stroop, director, API Department of Accident Prevention, it is doubtful whether oil companies would favor a national standard which might necessitate changes in current practices and require re-education of all operating personnel.

There is some possibility of a trend in legislation to enforce the use of color. Already one state, California, has adopted laws pertaining to equipment identification. A "Petroleum Safety Orders—Refining, Transportation, and Handling" which became effective on July 13, 1946, makes mandatory the use of color and identification markings on piping, vessels, and tanks. It states, in part:

". . . Each stationary tank or vessel containing flammable, corrosive, or poisonous substances shall be identified by a letter, number, name, or a combination of these . . . Pipelines containing flammable, corrosive, or poisonous liquids or gases shall be identified to indicate their contents or purpose . . . The identification . . . shall be by name or color . . . This shall not prohibit identification by the use of both a name and a color. . ."

The majority of refinery safety directors agree that color is definitely needed, not only for safety hazards, but also for piping identification. That one company already uses a complete color code, and several others a modified or simpler form indicates the trend toward the use of color as a specific refinery tool.

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Plastic Makers Look To Petroleum Chemicals for Raw Materials

By B. H. WEIL, Chief of Technical Information Division,

State Engineering Experiment Station, Georgia School of Technology

Present expansions planned for the plastics industry will provide for production at 200% of the 1945 rate, which in turn was almost double that for 1941 despite shortages in materials. Emphasis in plastics production has shifted from the cyclic resins, largely coal-tar chemicals, to acyclic resins most of which are capable of being produced from petroleum derivatives.

Prodution of coal-tar chemicals is not likely to increase in the future and the plastics industry will give greater attention to petroleum as a source of its raw materials. The approach of the oil companies may be either through present high-cost intermediates, demand for which can be increased through lower cost manufacturing; or intermediates now in high volume demand where lower cost production than at present figures may yield profits. Economic factors for the oil company to consider are presented.

PREDICTIONS of a postwar recession in the plastics industry have proved so wrong that a reappraisal appears in order on behalf of the petroleum refiners who are growing suppliers of materials used in plastics production.

The plastics industry is already overburdened with problems concerned with increasing fabricating capacity to meet a swelling demand, and obtaining, or itself producing, chemical intermediates in sufficient quantities to keep present equipment operating at anything near capacity. However, a number of misapprehensions have developed as to the place plastics will take in the industrial world, some of which can now be laid at rest.

The first of these misunderstandings is that plastics are, per se, competitors of and replacements for metals. With this in mind, many uninformed persons have tried a few plastics in their products and perhaps have even marketed some. They have met with failure because impossible things were attempted, and they have sworn never to use another plastic again when something else can be had.

Others have designed plastic articles for mass production without proper regard to material supplies, only to find that plastics, like all materials of construction, are in short supply. The public has contributed to this confusion by expecting plastic houses, plastic automobiles, and plastic articles of every type. The public has become disgusted when those plastic items it does obtain fail to meet tests which no one would dream of applying to articles made of other substances.

Confusion has also been caused by the popular association of plastics with only solid articles. There is only slight understanding of so-called plastic paints, plastic finishes for textile fibers, synthetic plastic fibers, and so on. Other misapprehensions are concerned with price. The public has the impression that plastics are inexpensive, money-saving substitutes for other materials. Yet it finds that certain manufacturers are charging unreasonable prices for plastic articles because they are glamorous and the manufacturers believe the public will pay for glamor.

Most of the present plastics market is soundly based, however; so soundly in fact that large expansions are in progress to meet unfilled demands. The present confusion, therefore, is little more than an annoyance but its potentialities are not hidden from the plastics industry. The industry as a whole continues to stress the fact that plastics are materials which should be used like other materials—where they are indispensable, better, or cheaper and they should not be used where they are inferior or unnecessarily expensive.

Plastic Statistics

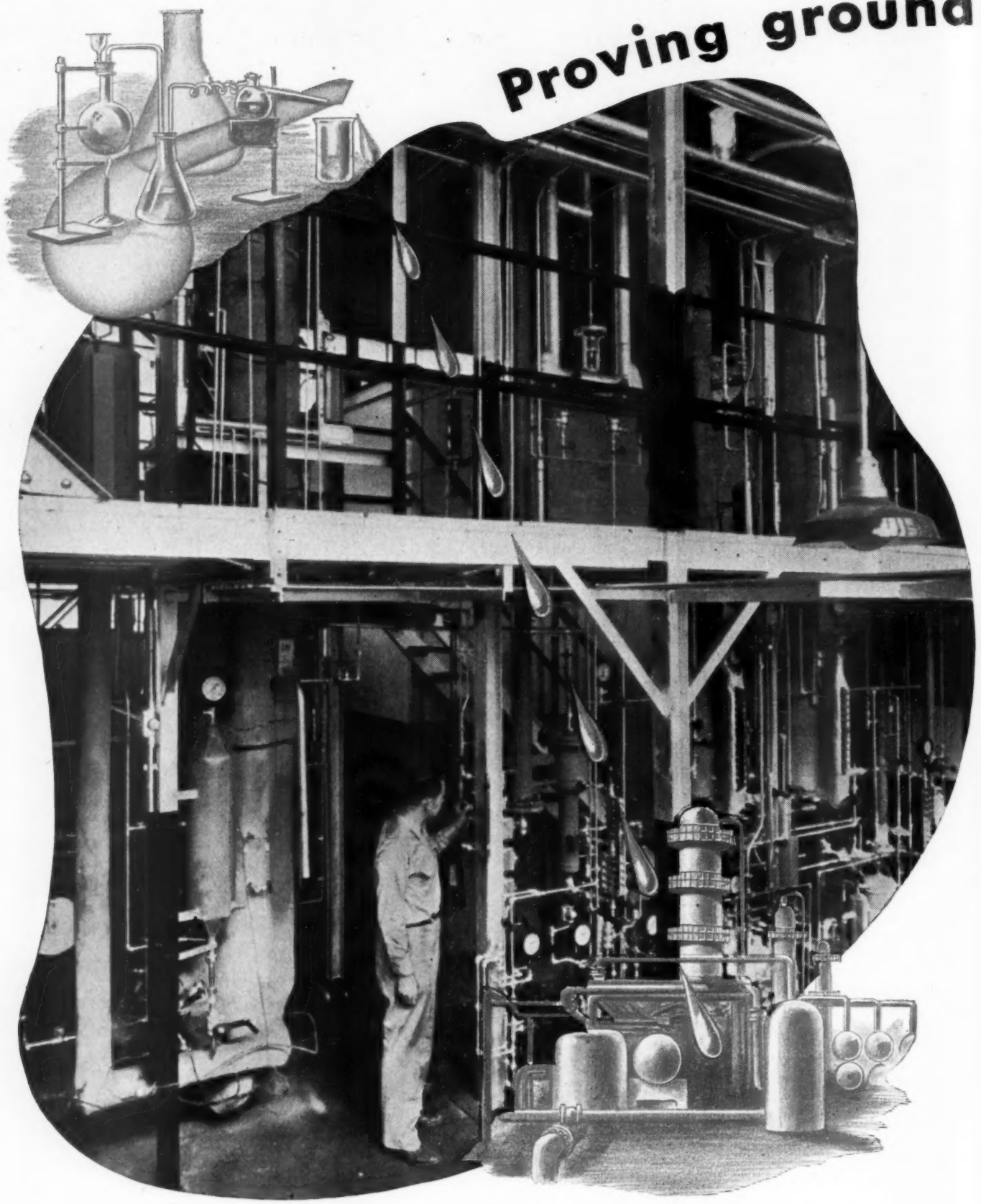
Several statistical reports released in 1946 contain figures which permit a quick survey of plastics expansion in recent years. This is particularly true for the synthetic resins, although data on the cellulose plastics are not lacking. Table 1 shows the proportionate uses to which

TABLE 1—Production of Plastic Materials Grouped According to Use During 1941-1945 (1) in Thousands of Pounds

Use, By Type	1941	1942	1943	1944	1945
Protective coatings	212,077	148,255	249,429	290,823	304,461
Cyclic	178,013	123,303	191,144	188,685	183,955
Acyclic	34,064	24,952	58,285	102,138	120,506
Molding and casting	121,684	122,745	130,416	119,915	160,223
Cyclic	91,220	72,306	75,281	72,270	93,222
Acyclic	30,464	50,439	55,135	47,645	67,001
Laminating	46,227	61,058	61,906	56,942	44,777
Cyclic	31,112	50,151	49,554	50,883	36,731
Acyclic	15,115	10,907	12,352	6,059	8,046
Adhesives	.....	8,817	60,667	81,785	79,025
Acyclic	.....	2,637	12,910	26,241	22,004
Cyclic	.....	6,180	47,757	55,544	57,021
Textiles(2)	.....	.....	19,486	26,421	30,958
Cyclic	.....	.....	540	793	1,303
Acyclic	.....	.....	18,946	25,628	29,655
Miscellaneous	72,182	99,124	132,034	203,466	188,790
Cyclic(3)	44,619	46,486	51,094	62,241	69,527
Acyclic(3), (4)	27,563	52,638	80,940	141,225	119,263
Total	452,170	439,999	653,938	782,352	808,234
Cyclic	344,964	294,883	380,523	404,113	406,742
Acyclic	107,206	145,116	273,415	378,239	401,492

(1) Compiled from U. S. Tariff Commission reports. Net resin content only.
(2) For 1944 and 1945 at least, this class also includes plastic materials used for paper and leather treatment.
(3) For 1944 at least, this figure includes a small amount of resin reported for ion exchange.
(4) For 1944 at least, this figure includes resins reported for glazing, sheeting, and films.

Proving ground



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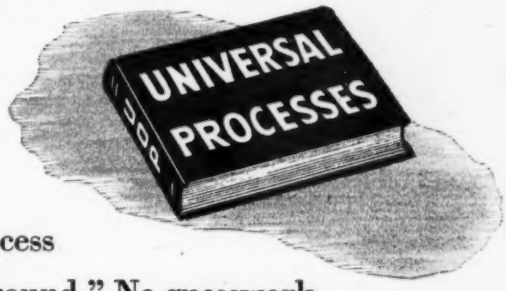

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synthetic resins have been put. In spite of wartime shortages, the production of synthetic resins in 1945 was almost double that of 1941, which, in turn was more than double that of 1939.

While these figures reveal trends in an industry whose output was under strict control for war production, they nevertheless indicate the pattern for the next few years; at least until new fabricating equipment comes into existence and material bottlenecks disappear. It is at once evident that, popular conceptions to the contrary, molded and cast resins do not at present account for the bulk of plastics production. While total resins production increased from 452,170,000 lb. in 1941 to 808,234,000 lb. in 1945, output for molding and casting increased only from 121,654,000 to 160,223,000 lb.

Protective Coatings Largest Single Use

The largest single use of plastics, amounting to over 30% in every year from 1941-45, was for protective coatings. Significant quantities went into laminating, a trend which should certainly continue. Large amounts were used for adhesives and increasing quantities were used for textile, paper, and leather treatment.

Another trend of basic importance was the shift in emphasis from the cyclic to acyclic resins. Prior to 1941, synthetic resins were classified as "coal-tar" or "non-coal-tar"—terms then generally synonymous with "cyclic" and "acyclic," respectively, since coal-tar derivatives are usually cyclic in nature. However, since that time the U. S. Tariff Commission has recognized the entry into the cyclic field of petroleum and other derivatives and has therefore shifted its classification to one of chemical structure, regardless of origin. This shift slightly falsifies the data for the last few years in Fig. 1, but not enough to warrant detailed correction. Certain acyclic alkyd resins, for example, are coal-tar derived, while certain cyclic resins (polystyrene, etc.) are as much non-coal-tar as coal-tar derived.

Keeping these facts in mind, it is significant to note that cyclic resins even including polystyrene increased in production only from 344,964,000 lb. in 1941 to 406,742,000 lb. in 1945. Acyclic resins increased almost four times in the same period, from 107,206,000 lb. in 1941 to 401,492,000 lb. in 1945. While this latter total was by no means all derived from petroleum, not even chiefly derived probably, it is significant that most of the plastics which fall in this class are capable of being produced from petroleum derivatives.

It is even more important to notice that acyclic resins registered their biggest gains in the two chief fields of plastic use, protective coatings and molding and casting, and that they already dominate most of the other plastic fields. This trend has chiefly been caused by the appearance and wide utility of such acyclic plastics as the vinyl resins, acrylic resins, polyethylene resins, etc. However, it is also attributable to the shortness of supply and inelasticity for expansion of the coal-tar chemicals. These chemicals are by-products of coking operations. The demand for coke, in turn, depends chiefly upon steel production, which is unlikely to exceed wartime levels for any extended period unless business conditions remain unusually good. Furthermore, strikes in the coal industry have repeatedly halted coking operations, thereby decreasing by-products production.

This last factor may eventually be eliminated, but the fact remains that the supply of coal-tar chemicals will not be greatly increased in the predictable future. Competition for them will increase. The plastics industry, therefore, will have to look elsewhere for new and more abundant sources of supply of presently known and even entirely new raw materials. This movement has already begun. The naphthalene shortage has encouraged the Standard Oil Co. of California to begin the production of phthalic anhydride from petroleum derived ortho-xylene. The production of benzene from petroleum may next be required, since this chemical is needed in increasing quantities for styrene plastics production, in addition to GR-S synthetic rubbers, and for the synthesis of phenol for the phenolic resins.

It is therefore logical that the plastics industry should give increased attention to petroleum as a source of plastics raw materials. The plastics industry is a large user of synthetic organic chemicals which have in recent years been prepared in increasing quantities from petroleum, for many uses.

The New Plastics

Before giving detailed attention to the position of the petroleum industry as a present and potential supplier of plastic raw materials, it may be wise to merely glance at recent developments in the plastics field. Table 2 shows the important plastics as known prior to 1940; plastics which since that time have become "established new materials"; and the most recent significant plastics. The listing in Table 2 is by no means exhaustive, nor are the lists indicative of trends in new resins for synthetic fibers, new adhesives, new laminating materials,

TABLE 2—List of Important Plastics

Important Plastics Prior to 1940

Thermosetting	Thermoplastic
Phenolic resins	Ethyl cellulose
Urea resins	Acrylic resins
Alkyd resins	Polystyrene resins
Thermoplastic	Polyvinyl chloride
Cellulose acetate	Polyvinyl acetate
Cellulose acetate-butyrate	Polyvinyl chloride-acetate
Cellulose nitrate	Polyvinyl butyral

Plastics which have become "Established New Materials since 1940"

Thermosetting	Thermoplastic
Melamine resins	Polyvinyl alcohol
Allyl resins	Polyvinylidene chloride
	Polyvinyl-polyvinylidine chloride copolymers

Most Recent Significant Plastics

Thermosetting	Thermoplastic
New alkyd resins	Silicone resins
Polytetrafluorethylene	Polyvinyl carbazole
Thermoplastic	Polydichlorostyrene
Polyethylene resins	Cellulose acetate-propionate
Nylon	

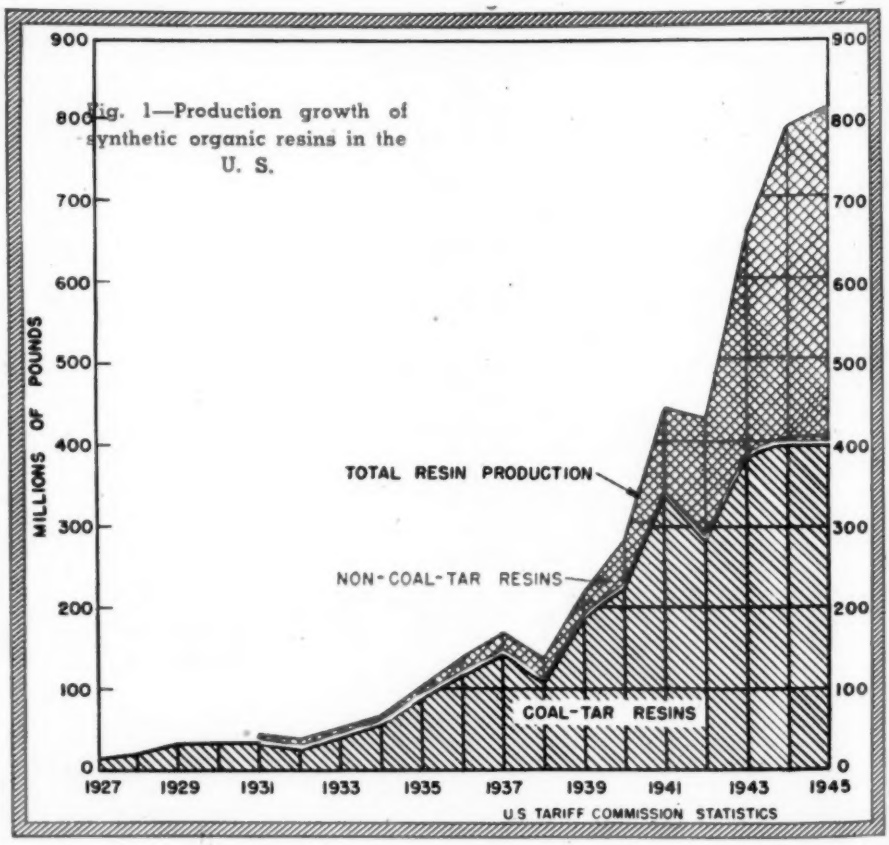


Fig. 1—Production growth of synthetic organic resins in the U. S.

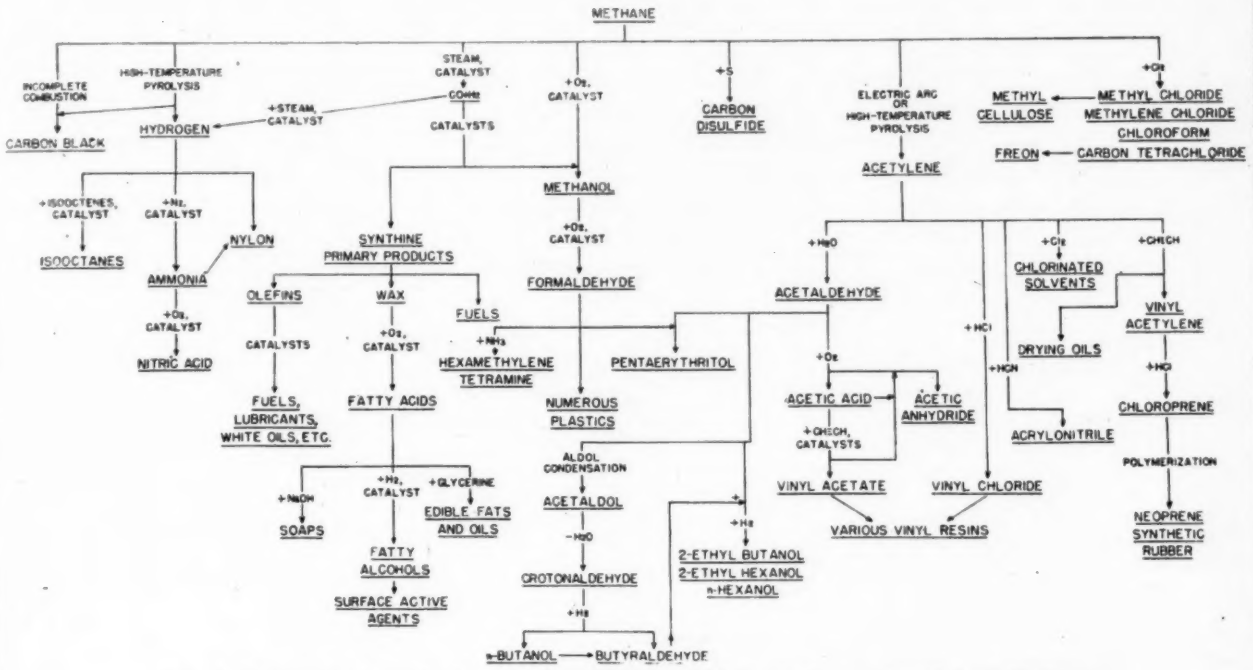


Fig. 2—Diagram of synthetic organic chemicals which can be produced from Methane

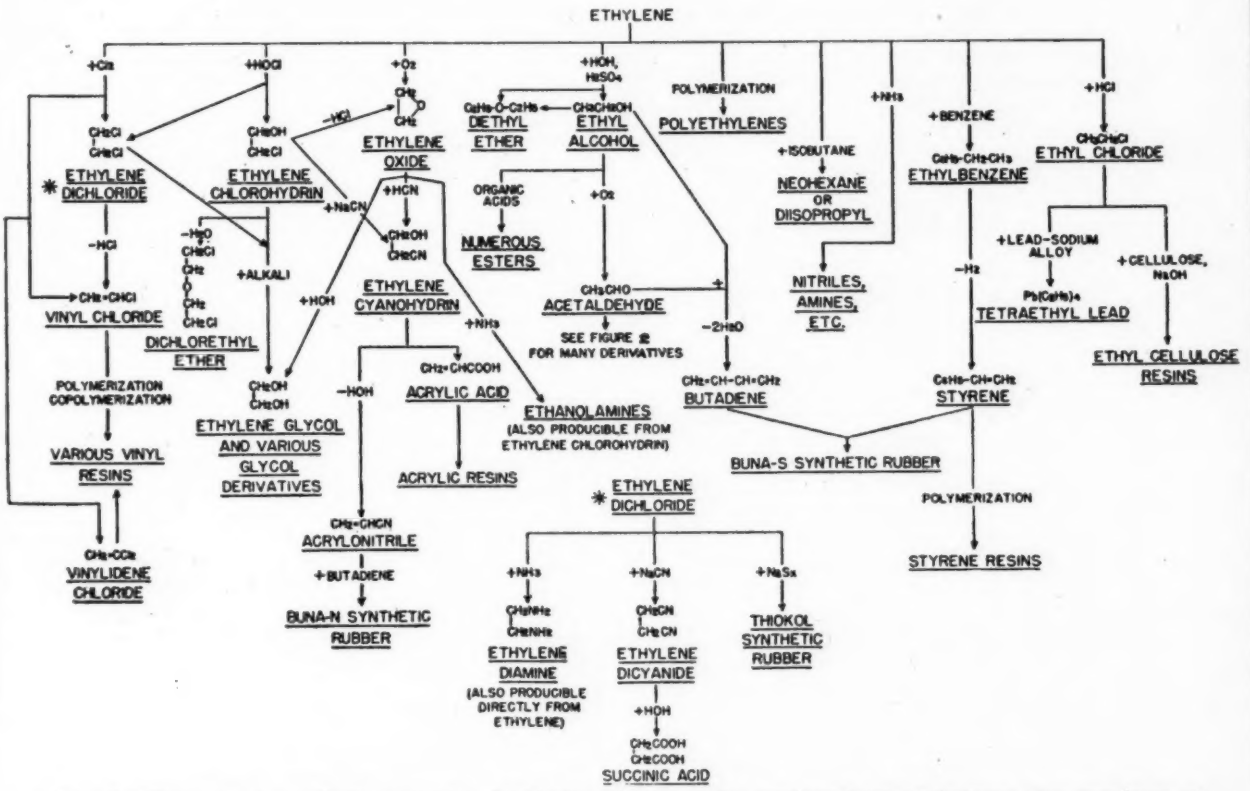


Fig. 3—Diagram of synthetic organic chemicals which can be produced from Ethylene. The synthesis of one petroleum chemical is closely related to that of several others and comparative chemical economics must always be considered

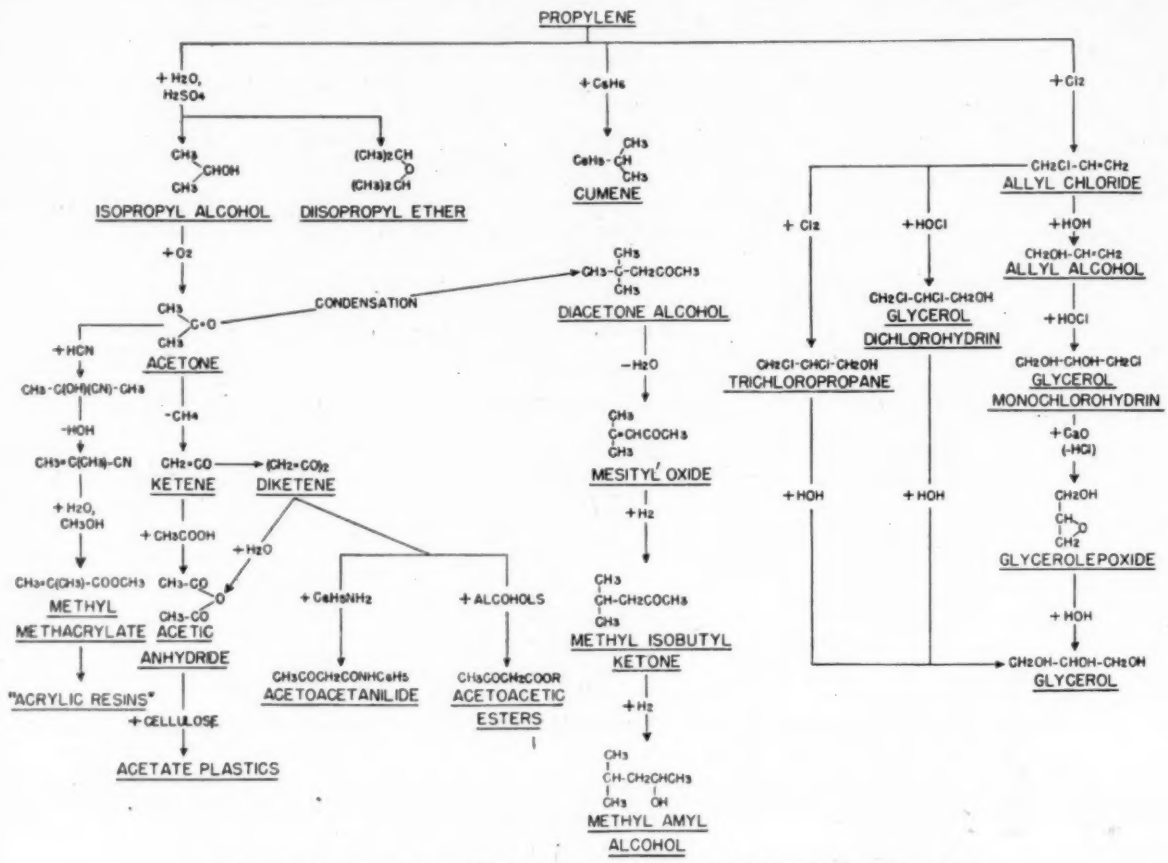


Fig. 4—Diagram of synthetic organic chemicals produced from Propylene

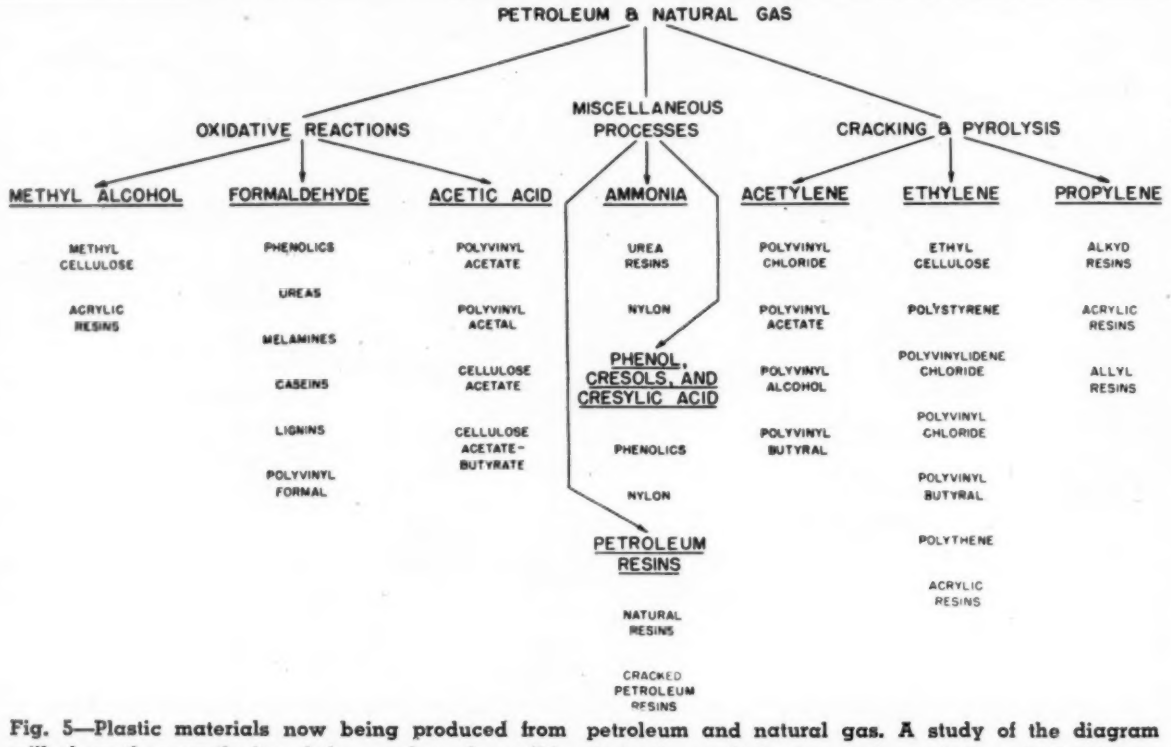


Fig. 5—Plastic materials now being produced from petroleum and natural gas. A study of the diagram will show the complexity of the number of possible derivatives which may and are being obtained from petroleum and natural gas

new wood and paper applications and new synthetic rubbers.

No detailed discussion of these new materials can be made here nor can attention be given to such important new plastic forming processes as molding with electronic heating; jet molding; low-pressure molding of laminates; mass production methods for plywood, and polystyrene extrusion. New forms of old materials, such as louvered, laminated cellulose acetate sheet; ethyl cellulose film; foam polystyrene; cellular cellulose acetate; and new synthetic finishes (melamine, etc.) also can be mentioned only in passing. However technical details on all these subjects are available in the literature.

Many individuals, laymen and scientists alike, tend to become confused by the number and chemical diversity of resins and plastics. As far as the petroleum industry is concerned, however, this problem is somewhat simplified by the fact that many plastics as yet bear no relationship to petroleum chemical derivatives and that few petroleum companies are really interested in producing and marketing finished plastics and plastic products. For the time being, therefore, petroleum industry attention to plastics is focused on the synthesis of plastic intermediates — petroleum chemicals. Along this line the writer earlier stated:*

"The complexity of the synthetic organic chemical industry is such that it is often impossible to say exactly what the basic raw materials for a substance have been. Formaldehyde, for example, is much used by the plastics industry; some 85,000,000 lb. were so consumed in 1941, and far larger quantities in each year since that date. A plastics manufacturer using this chemical, obviously, either produces it himself or buys it. In any particular instance, the basic raw material probably can be identified.

"But if one is to view in the abstract the various commercial methods of producing formaldehyde—the oxidation of methanol (obtained from wood distillation or by synthesis from carbon monoxide and hydrogen, in turn obtainable from coke or from natural gas) or the oxidation of natural gases such as butane, one would be hard put to say that a substance made from formaldehyde cannot be classified as a petroleum derivative even if no plastic producer is currently using formaldehyde so derived in his particular product. This statement can be extended to phenol, urea, methyl methacrylate, and to all of the plastics chemicals which are being commercially produced from several different basic raw materials. If these chemicals can be made economically from petroleum hydrocarbons, then plastics made in turn from them can be considered plastics from petroleum just as truly as they may be called, for example, plastics from coal."

Synthetic organic chemicals have in recent years been produced in great diversity and large quantities Figs. 2, 3, and 4 are indicative of this trend. These figures contain synthesis outlines for the preparation of most of the "petroleum plastics"—polyvinyl chloride, acetate, and butyral; polyvinylidene chloride; acrylic resins; polystyrene; ethyl cellulose; cellulose acetate; cellulose acetate-propionate and acetate-butyrate; nylon; etc. They emphasize the fact that the synthesis of any one petroleum chemical is closely related to that of any one of several others and that—patent entanglements aside—comparative chemical economics must always be considered. Fig. 5 shows the plastics materials derived from petroleum and natural gas.

The economics of petroleum chemicals are too complex for detailed discussion in this review, but a brief summary of the salient points should prove of interest to any petroleum refiner considering becoming a manufacturer of chemicals:

1. A synthetic, no matter how cheap, can rarely completely displace a byproduct but instead can only supplement it. Glycerol, for example, is a byproduct of soap manufacture, and cannot be dislodged by the synthetic material.

2. No matter how easy it may be to manufacture a hydrocarbon derivative, there can be no profit in it unless a market exists or can be developed. Tertiary butyl alcohol, for example, was first produced some 19 years ago, but operations had to be discontinued because of lack of a market. Manufacture was resumed only after technologic advances created a demand for this chemical.

In this connection, it should be noted that rarely has a new chemical been produced without ultimately creating a demand for itself. The interim between its supply and demand, however, may be of such duration that only a financially strong company can afford to invest in the development of a substantial market. Certain resins, moreover, like those derived from methyl vinyl ketone or from sulfur dioxide and olefins, were developed on a semi-commercial scale several years ago, but are as yet unsuccessful. Creation of a market in these instances depends upon improvement of the physical and chemical properties of the products—a slow, costly, and as yet unachieved research project.

3. A small, expanding market is more attractive than a large, static one. The historical evolution of acetic anhydride is an excellent illustration of this fact.

4. The ideal products are those that have expanding markets and that are rapidly destroyed in use. Petroleum's bulk products are of this type. There are very few hydrocarbon derivatives in this category at the moment.

5. The most profitable lines of research are those directed at low-cost manufacture of intermediates which are now expensive but which are required for products of high quality. Certain highly attractive resins, for example, while recently made in large volume for military uses, are probably too expensive to find wide peacetime application in competition with the phenolics.

With these things in mind, a petroleum company may advisedly contemplate entering the field of chemical derivatives when one or more of the following situations prevail:

1. It has available a large volume of a certain raw material required for the manufacture of a chemical consumed in considerable quantities.

2. It has at hand a unique raw material capable of serving in the production of a new and potentially important industrial chemical.

3. It is wasting large volumes of a by-product, such as natural gas or refinery sludges, which might be converted economically to useful materials. The chemical utilization of wastes is an essential part of a national program of conservation.

4. It is able to develop a strong patent position in the production of a chemical of present or potential large-volume demand.

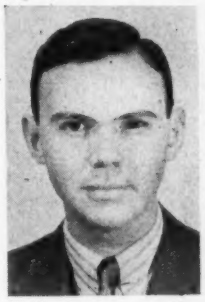
5. It can economically manufacture additives required to enhance the value of its own bulk products, or can produce chemicals which can be sold in place of others currently purchased.

6. It possesses sales and technical service staffs with well-established contacts with another industry which is a

* Weil, B. H., *Petroleum Refiner* 24, No. 1.89 (1945) "Plastics from Petroleum."

The Author

B. H. Weil is Chief of the Technical Information Division of the State Engineering Experiment Station, Georgia School of Technology, Atlanta. He was the founder and for five years head of the Information Section of the Chemistry Division, Gulf Research & Development Co., Pittsburgh. He is a senior author of the recent book, "Plastic Horizons", and the author of numerous articles on the subjects of plastics, petroleum chemicals, synthetic fuels and lubricants, among others.



Mr. Weil

Photo courtesy du Pont Co.

Nylon flake being fed into hopper of spinning machine, where it is melted and extruded into filaments. When a new plant at Orange, Texas, is completed, nylon will become a petroleum plastic and fiber

potential consumer of its chemical products.

Once it has been determined that at least one of these conditions prevails, other questions must be settled. How well adapted is existing equipment to the manufacture of chemical derivatives? To what extent should a plant undertake new construction? How far should a company go in converting its raw materials into finished chemical products? What idiosyncrasies of chemical economies need be considered? What form of company organization should be set up to manufacture and market chemical derivatives? What kind of a research program is necessary?

It is beyond the scope of this article, also, to consider technical details of petroleum chemical synthesis. The following conclusions may be presented, however, as based on available data.

These figures, together with Figure 5, make it possible to intelligently appraise Tables 2 and 3 from a petroleum chemicals viewpoint and to arrive at the following conclusions:

1. The most important cyclic plastic materials at present are the phthalic anhydride-glycerol alkyd resins, the phenol-formaldehyde resins, the polystyrene resins, and the coumarone-indene resins. All but the latter *may* be produced from petroleum chemical intermediates. Phthalic anhydride, glycerol, formaldehyde, and styrene are now being produced in varying quantities from petroleum hydrocarbons.

Other petroleum chemicals used to synthesize the cyclic resins (*formerly* the "coal-tar resins") are pentaerythritol, glycol, allyl alcohol, cresols and cresylic acid, acetone, dichlorostyrene, and, of course, small quantities of the "petroleum polymer resins." Many of these chemicals are derived only in part from petroleum, but all are capable of such derivation.

2. The most important acyclic plastic materials at present are the maleic anhydride-based alkyd resins, abietic acid-glycerol rosin esters, urea-formaldehyde resins, melamine-formaldehyde resins, polyvinyl chloride and chloride-copolymer resins, other polyvinyl resins, polyvinylidene chloride resins, and the acrylic resins (chiefly polymethyl methacrylate). Petroleum chemicals which could be (or are being) used for their synthesis include maleic anhydride, glycerol, urea, formaldehyde, vinyl chloride, vinyl acetate, vinyl butyral, vinylidene chloride, and methyl methacrylate.

3. The chemically modified cellulose plastics can use the following petroleum chemicals: cellulose acetate—acetic acid and anhydride; cellulose acetate-propionate—propionic acid and acetic anhydride; cellulose acetate-butyrate — butyric acid and acetic anhydride; ethyl cellulose—ethyl chloride; methyl cellulose—methyl chloride; cellulose nitrate —ammonia.

A glance at the list of new plastics indicates that many of these, also, can be derived from petroleum. Polyethylene resins are petroleum derivatives, and nylon will become one, to some extent, when a new du Pont plant in Texas, to use cyclohexane, is completed.

Future of Plastics

Latest available data on the plastics expansion program for the immediate future indicates that, while the output of polystyrene for 1946 increased over 128% over the 1945 record figure, it is believed that the late 1947 rate will provide polystyrene at a rate almost 10 times as great as in 1945; i.e., about 200,000,000 lb. per year. Cellulose esters production totaled 61,123,000 lb. in 1945, probably increased to 82,000,000 lb. in 1946, and may amount to 120,000,000 lb. in 1947. All of these figures and most of those which follow, incidentally, are for molding powders only.

When new facilities are completed, late in 1947, the output of the vinyl resins should amount to 2.4 times the 1945 production rate, which was at a rate of 119,600,000 lb. per year in April, 1946, and potential markets may be ten times this figure.

Manufacturing capacity for phenolic molding materials is also in the process of being doubled, as are the capacities for urea and melamine. Production of synthetic resin adhesives, incidentally, has increased from 25 to 90% over 1945, and the output of acrylic resins, nylon, polyethylene has been materially increased.

After presently-planned expansions are completed, the output of thermoplastic molding powders (vinyls are not included) will be at 360% of the 1945 rate, that of thermosetting molding powders at 192% of the 1945 rate, and that for all molding powders (vinyls not included) at 256% of the 1945 rate.

For all plastics (including cellulose plastics, resins for protective coatings, etc.), estimated production after expansions are completed will be at 200% of the 1945 rate.

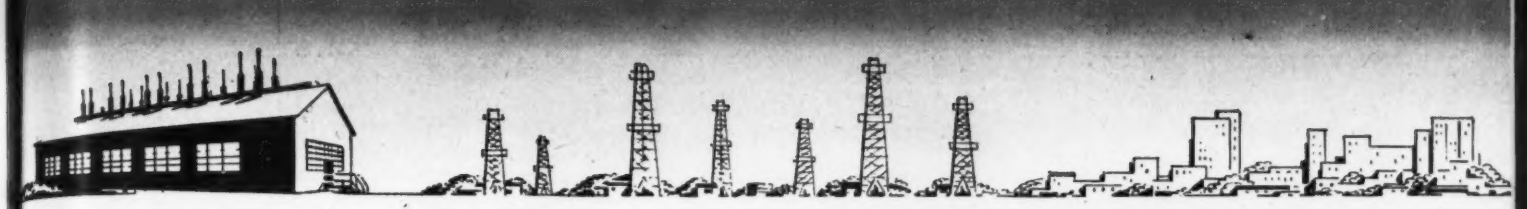
In spite of all these expansions, the plastics industry does not believe that sufficient materials will be produced to operate its fabricating machines to capacity. "When the present injection and extrusion capacities together with pending expansions are considered, there is still a shortage, if full operation of plastics machinery is to be maintained," one authority has stated. Materials for

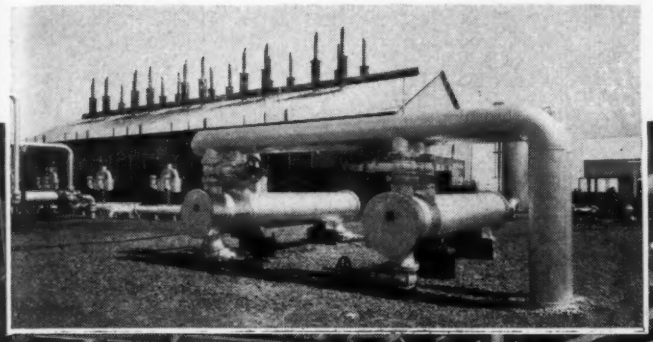
TABLE 3—Production and Sales Price of Some of the More Important Plastic Materials 1944-1945[1]

Material	1944 Production (1000 lbs.)	1944 $/lb.	1945 Production (1000 lbs.)	1945 $/lb.
Cyclic Plastic Materials	404,113	0.22	406,742	0.25
Condensation Resins, benzenoid	334,396	0.24	323,018	0.29
Alkyds, total (includes Phthalic anhydride-glycerol and phthalic anhydride-pentaerythritol types)	132,402	0.19	134,705	0.23
Tar Acids, total (includes phenolics and phenolic-formaldehydes)	197,315	0.28	186,501	0.32
Polymerization Resins, benzenoid (includes polyaromatic and polystyrene types)	69,717	0.10	83,724	0.12
Acyclic Plastic Materials	378,239	0.40	401,492	0.46
Condensation Resins	171,545	0.23	190,557	0.23
Alkyds, total (includes maleic, abietic, and fumaric acid, and anhydride-terpene types)	105,481	0.17	53,165	0.25
Rosin esters, unmodified, (includes abietic acid-glycerol, -pentaerythritol and other polyhydric alcohol types)	[2]	[2]	65,977[2]	0.12[2]
Organic nitrogen resins (includes urea, and melamine-formaldehyde types)	66,064	0.33	.....	...
Polymerization Resins	206,694	0.59	210,935	0.67
Polyvinyl, total (includes polyvinyl halide alcohol, and other types)	126,892	0.48	122,507	0.42
Alcohol polymerization resins (includes allyl and furfuryl alcohol types)	373	0.89	.....	...

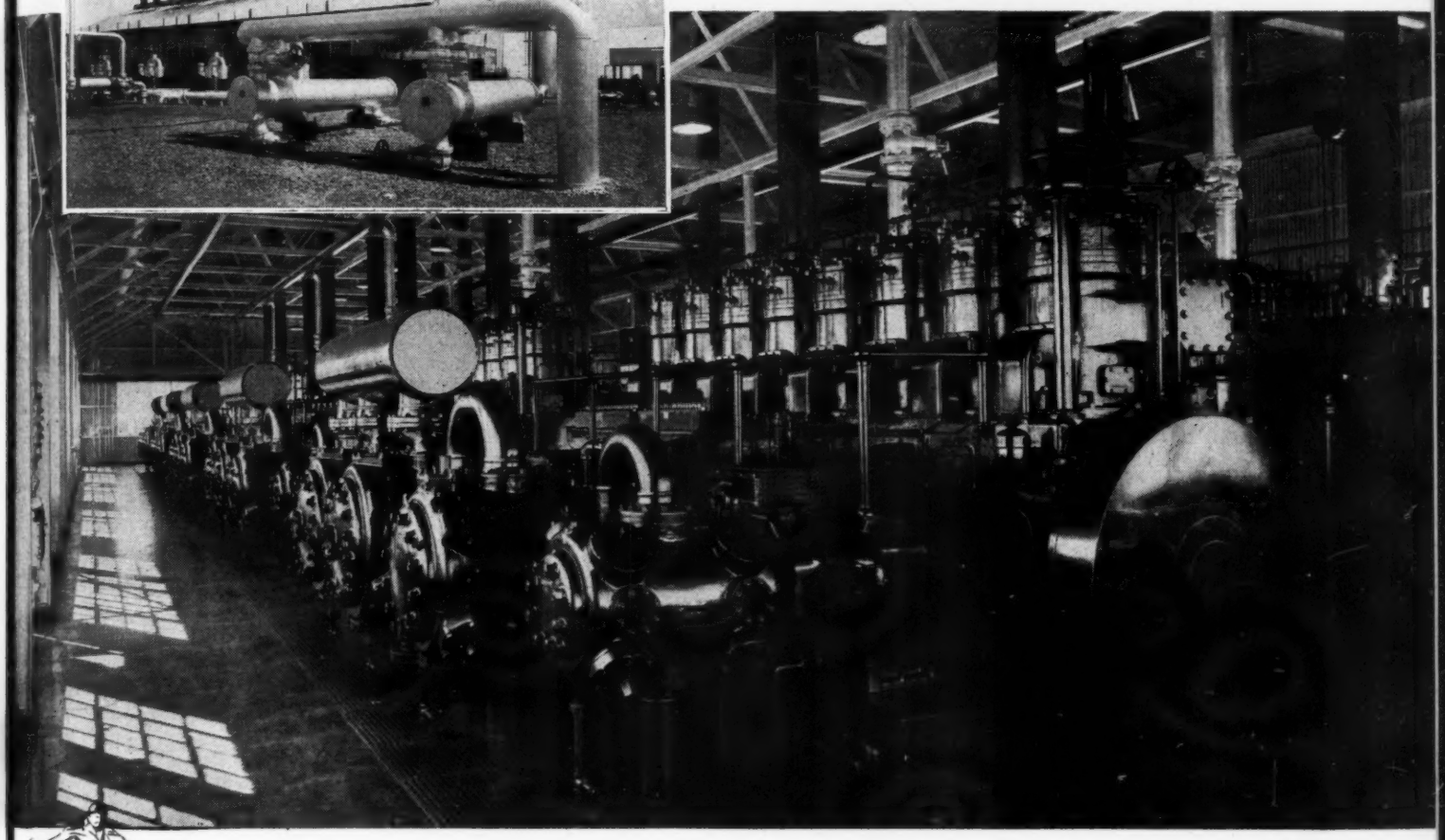
(1) Figures are from U. S. Tariff Commission reports and are for net resin content only; 1945 figures are preliminary.
(2) Until 1945, unmodified rosin esters were reported with alkyd resins. For this reason, care must be used in making comparisons.

JUST WEST OF BEAUMONT, TEXAS...





The McCarthy Oil & Gas Corp. gasoline absorption plant at Winnie, Texas, uses ten 8-cylinder (800 BHP) Clark RA Compressors. After natural gasoline is extracted, residue gas is furnished to nearby companies.



Just 25 miles southwest of Beaumont, Texas, is the gasoline absorption plant of the McCarthy Oil and Gas Corporation. Here natural gas is gathered from the field, compressed and then put through an absorption plant where the natural gasoline is extracted. In this plant, ten 8-cylinder (800 BHP) Clark Right Angle Gas-Engine-Driven Compressors are equipped with the proper compressor cylinders to give three stages of compression.

McCarthy Oil and Gas Corporation selected these Clark units for their absorption plant at Winnie, Texas, after a thorough field investigation to determine the unit that was most applicable to their particular problem, especially in relation to:

1. Reliability of operation. 2. Low installed cost per horsepower. 3. Low operating cost, and 4. Low maintenance cost.

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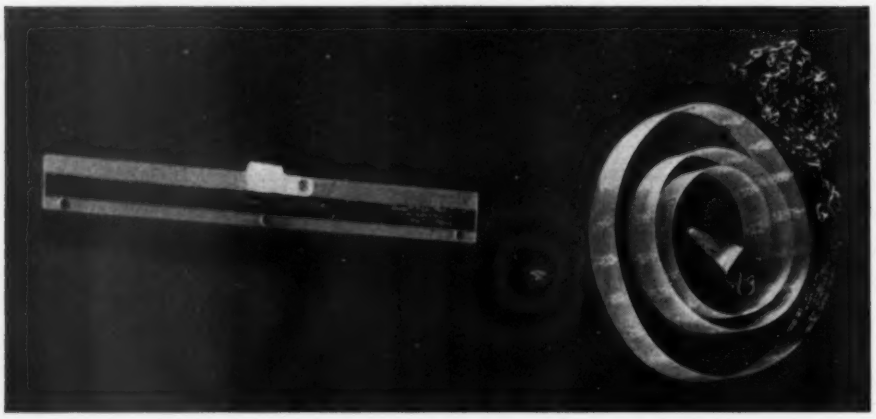

Photo courtesy du Pont Co.

Some plastic gages for fuel tanks are made from cellulose acetate and others from acrylic resin. Their frosted surfaces turn clear when wet, indicating distinctly the quantity of oil in the tank. Above left, a gage rule which fits over a regular steel gage tape for large bulk measurements. Above right, a gage for a 550-gal. outdoor tank

other plastic uses will also be short.

If plastics production continues to increase at the 1939-1945 rate, total production by 1955 will be 2,500,000,000 lb.; if raw material production continues to double every five years for the next ten, as another authority predicts, it will amount to 3,600,000,000 lb. in 1955. Perhaps the actual will fall somewhere between the two.

Nor are the plastic intermediates themselves the only chemicals required. The compounding of plastics requires quantities of plasticizers and solvents.

Petroleum Industry's Role

What does all this mean for the petroleum industry? Briefly, it adds up to a golden opportunity to enter the petroleum chemicals field with markets for certain products assured, providing competitive costs can be met and the previously-mentioned prerequisites for petroleum chemicals taken into account.

Many chemical companies are already expanding their plants which produce petroleum chemical intermediates for plastics, among them Carbide and Carbon, Dow Chemical Monsanto and Celanese Corp. Those petroleum companies already in the field are following suit.

As regards points of entry for new producers, these must be decided on the basis of the aforementioned prerequisites, especially the availability of raw materials and marketing outlets. Reference to Table 3 will give some indication of the price structure for the plastics themselves, while several chemical journals carry chemical price lists for the intermediates identifiable from Figs. 2, 3, 4, and 5.

For example, a brief survey of the field in 1943 indicated that the following plastics chemicals might be of special interest to petroleum research:

(1) High-cost intermediates, demand for which might be increased through lowered costs, such as methyl methacrylate (hydrogen cyanide, acetone, methanol), ethyl chloride, vinyl chloride, styrene, vinylidene chloride, methyl chloride, and vinyl acetate.

(2) Intermediates which might yield profits through low-cost quantity production, such as acetic acid (acetylene), acetic anhydride (acetone, acetylene), ammonia, normal butanol (acetaldehyde) butyraldehyde (acetaldehyde), cresols, phenol (benzene), xylenols, methanol, formaldehyde, and cyclohexane.

The situation has changed materially since this analysis, of course, but the point remains the same—a choice must often be made between producing intermediates for high-cost but low-quantity plastics and low-cost, high-quantity plastics.

No attention has been given here to the synthetic rubbers and synthetic textile fibers, although their economics and raw materials are closely related to the plastics field.

The production of, say, 50% of the raw materials in 1955 for a plastics industry producing, say, 3,000,000,000 lbs. of plastics per year would not require more than a few per cent of petroleum production even at the present rate, but such chemical production would be measured in cents per pound instead of cents per gallon.

The petroleum industry, then, seems certain to pay increasing attention to the trend toward manufacture of plastics from petroleum bases, both because this trend is economically sound from a chemical viewpoint and because the plastics industry gives every sign of becoming a mass production field which will require large volumes of raw materials.

No industry is really depression-proof, but potentialities for plastics production —new and old—are so tremendous that raw material suppliers may look upon this field as at least a stable materials user if not a rapidly increasing customer.

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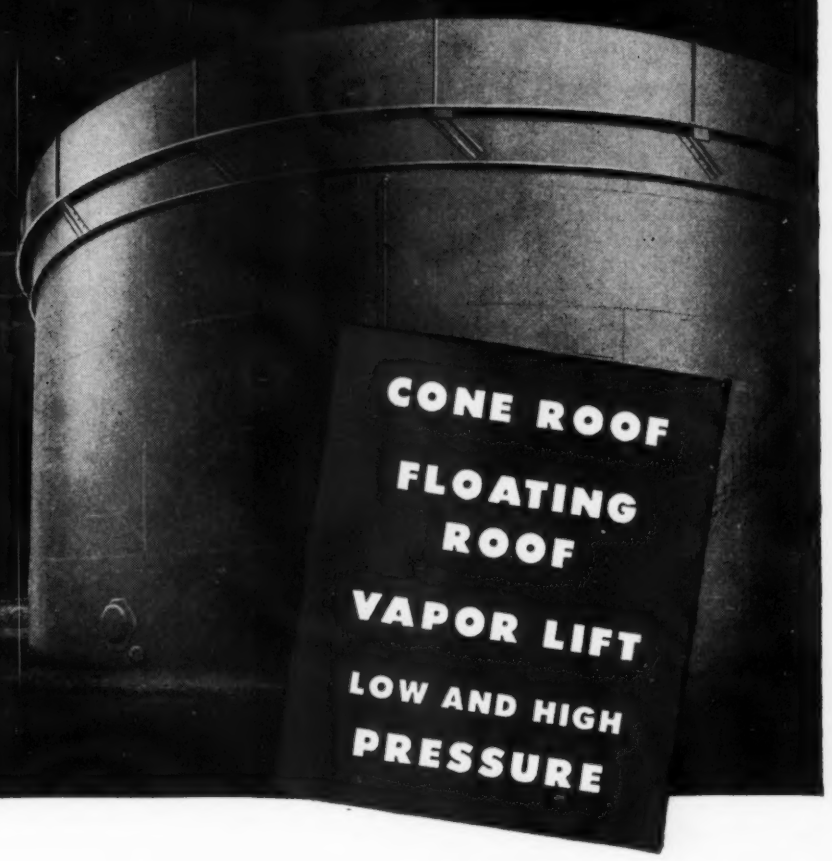

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Carefully Planned Work Schedules Aid in Clean-outs of Refinery Units

By JIM WALLEN, Ashland Oil & Refining Co.

PREPARATION of three carefully planned work lists is the most important part of the intensive advance work preceding a unit clean-out at the Ashland Oil & Refining Co. refinery near Catlettsburg, Ky.

One list, schedules all routine cleaning and repairs to be done on each piece of equipment on the unit. For example, Fig. 1 shows a partial listing of jobs on the schedule for a shutdown of a Dubbs cracking unit. Space is provided for the checking of each item by the three interested departments—inspection, operating, and maintenance. Signatures of men in authority for each department are required before the job is considered satisfactorily completed.

A second list, shown in Fig. 2, is for all special jobs, non-routine items that are to be taken care of at the time of clean-out. Again space is provided for checking by all three departments involved.

The third list, Fig. 3, covers the furnishing of proper safeguards during shutdown. It schedules the necessary "blinds" to be installed before actual work begins and to be removed before operations are resumed. The list as shown in Fig. 1 includes space for signatures of those responsible for installation and removal of the blinds.

Planning Follows Definite Schedule

When a shutdown is in prospect, the first step in the Ashland system is a get-together of the operating superintendent and the metal inspector. These two men draw up an itemized list of all work which should be done.

For example, the metal inspector keeps an up-to-date record of every piece of piping, every pump, exchanger, and other operating equipment. His record tells him how long an item has been in service, when it was last inspected, and what repairs or replacements were made.

"If we notice that a certain exchanger has gone for some time without requiring any repair work, we put it on the list to be gone over when the next clean-out begins, even though this particular exchanger may apparently still be in good condition," explained John R. Rosson, operating superintendent.

Mr. Rosson, along with Max Bruner, metal inspector, is largely responsible for the planning and execution of the Ashland system.

As the list is worked out, the operating superintendent may have some items for inclusion such as leaking valves, pump repairs, installation of a steam smothering line, or a change in process piping, all of which would not normally come within the knowledge of the metal inspector.

As the illustrations show, the final lists group the various related items under the proper headings for convenience. There is virtually no possibility that any job will be overlooked. If missed by one department, it will certainly be caught by one of the other two.

"Some may say," commented Mr. Rosson, "that this system takes too much time, but we have found the immediate results worth it. In the long run, it results in a saving of time. There is never any question later as to whether a certain job was performed, who did it, or how it was done." No unit is put on stream until every item on the work schedule has been checked by all three departments.

Another factor entering into the work schedule is the maintenance book which

ROUTINE REPAIRS AND INSPECTION
ON DUBBS CLEANOUT

Insp. Dept.	Oper. Dept.	Maint. Dept.	
			Heavy Oil Heater
			1. Clean tubes in heater.
			2. Clean transfer line into reaction chamber.
			3. Clean and align oil and gas burners.
			4. Lay loose brick in inspection doors.
			5. Clean firebox of all debris.
			6. Clean header compartment drains.
			Light Oil Heater
			1. Clean tubes in heater.
			2. Clean naphtha bank.
			3. Clean #2 transfer line into reaction chamber.
			4. Clean and align oil and gas burners.
			5. Clean debris from tunnel and firebox.
			6. Insulate cracks around header compartment doors after startup.
			7. Clean header compartment drains.
			8. Replace all header compartment plates.
			Reaction Chamber
			1. Clean coke from reaction chamber.
			2. Clean wall washing flange on H.O. transfer.
			3. Clean and inspect all transfer and drawoff valves.
			Flash Chamber
			1. Clean coke from flash chamber.
			2. Check weighted spray with water.

Fig. 1—Part of a schedule for routine repairs and inspection to be done on each piece of equipment on a Dubbs unit. Signatures of officials of each department are required in the space provided before the unit is put back on stream

RECOMMENDED LIST OF SPECIAL JOBS
DURING DUBBS CLEANOUT

Insp. Dept.	Oper. Dept.	Maint. Dept.	
			Heavy Oil Heater
			1. Inspect steam smothering lines, repair as necessary.
			2. Repair asbestos stripping on header compartment doors.
			*3. Install plug and chains on header compartment drains.
			Fractionator
			1. Remove inspection plates on top 9 bubble trays.
			*2. Replace remaining dished manway cover plate.
			Flash Chamber
			1. Line 8" vapor inlet nozzle with 12% chrome.
			*2. Line 10" liquid level nozzle with 12% chrome.
			3. Line exposed portion of bottom head with 12% chrome.
			4. Line extension neck with 12% chrome.
			Stabilizer
			1. Pressure test stab. reboiler bundle to 1½ times working pressure.
			Piping
			*1. Enlarge naphtha charge line according to drawing 2980-A.
			*2. Install piping from isoflow heater to stabilizer reboiler.drawing 2973-A.
			*3. Chrome line Sec.1 main fractionator leg (12" Hvy. H.O. Pump Suction)
			4. Remove Sec. 9, 8" tee for inspection L.H.O. Pump Suction.
			*5. Renew header (6x4x4) on Hvy. H.O. Pump

Fig. 2—Special jobs—"must" items—are listed on a separate sheet and scheduled for handling at the time of clean-out. Those items marked with an asterisk (*) require work prior to the shutdown

is kept at each unit. All operators and shift foremen record in this book any items they believe should be included in the next schedule. The operating superintendent makes a close study of the maintenance book and gives thorough consideration to each suggestion.

Clean-out Discussed in Meeting

After the lists are completed, copies are posted in the operating rooms and distributed to all process, mechanical, and engineering foremen. The operating superintendent then calls a meeting of the foremen and the metal inspector to discuss the work to be done and to arrive at an outline of how it is to be undertaken.

The metal inspector will know that a piece of pipe listed has been corroding at a certain rate for the past three months. He will therefore have the prefabricating work on an exact replacement begun so that as soon as the unit is shut down, the used pipe can be removed and its replacement fitted quickly in its place.

The mechanical foremen figure out what jobs will be the biggest and the most difficult, and arrange to start them as soon as possible. They also decide on work assignments, and check on condition and quantity of required tools so as to avoid delays on that point.

The shut down is then ordered. The unit is taken off stream in the evening, steamed four to five hours, washed, cooled down, and tested for safety with the vapor indicator, so as to be ready for the mechanical department the next morning. All blinds are installed as per the blinds list, as shown in Fig. 3. It is Ashland's policy to never trust a valve. "Valves can leak," pointed out Mr. Rosson.

If the vapor indicator shows the presence of one twelfth of one percent or more of vapor, the unit is classified as still unsafe, and further purging ordered.

Putting the plant back on stream is also an operation requiring care and thoroughness. After the two major work lists have been approved and all blinds removed, a final pressure test with oil is made. Then circulation and heating is begun, and after five to six hours, regular processing is again underway.

A welding torch is used to burn out the coke from the inside of a valve during the cleanout, one of the jobs included on the routine work list

Fig. 3—Part of the operators' check list for the installation and the removal of blinds during a Dubbs unit clean-out. Used in Ashland Oil & Refining Co.'s system, the list provides space for official signatures just as in the forms shown in Figs. 1 and 2

DUBBS CLEANOUT OPERATORS' CHECK LIST

DATE _____

BLINDS TO BE INSTALLED DURING DUBBS CLEANOUT

End of Run No._____ Date of Shutdown_____

LINE	NO.	SIZE	LOCATION	CREW TO INSTALL AND REMOVE	INSTALLED CHECKED BY:	REMOVED CHECKED BY:
Charge to Fractionator	2	4"	W. side 2nd platform. One at tee where line goes to 2 inlets. One at valve where other 3" ties in.	Columns Crew		
Charge to Fractionator	1	4"	W. side 2nd platform. One at tee where warm-up line ties into charge line	Columns Crew		
Fractionator Overhead vapor line	1	12"	At elbow on top of fractionator.	Columns Crew		
Low pressure cooling oil return to fractionator	1	6"	E. side of 2nd platform. On top of cross above manifold.	Columns Crew		
Fractionator relief line	1	8"	S. side of 2nd platform next to relief valve.	Columns Crew		
Fractionator drop out lines	2	3"	S. side of fractionator structure. At eye-level flanges tying into 8" pop-line.	Columns Crew		
Vapor line from Flash Chamber	1	10"	E. side of fractionator 2nd platform at elbow of 10" line into fractionator	Columns Crew		

BUBBLE PLATE COLUMN DESIGN

By ROBERT R. WHITE

Associate Professor
Department of Chemical and
Metallurgical Engineering
University of Michigan

Last month the author presented the first of two articles discussing some of the factors involved in the design of fractionating columns. This month he concludes the general subject of bubble plate columns, covering downspouts, bubble caps, plate spacing, tray layout and reboil heat.

Previous articles in the series described methods for calculating process variables in fractional distillation and their relation to tower design.

Downspouts

AS INDICATED in the previous section, downspouts or downcomers are usually circular conduits through which liquid passes from one plate to the plate below. The downspouts need not be circular but may be chord shaped where the raised edge of the downspout serves as a weir. In large columns, where liquid is removed from the center of a plate, the downspout may be formed from two parallel plates extending across the diameter of the column.

Under normal operating loads, the downspouts are partially filled with liquid and their operation is that of a submerged orifice. Thus, the standard orifice equation with a discharge coefficient of 0.5 may be used to calculate the friction head loss(1).

$$Q = 0.008 A h_1^{0.5} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

h_1 = head loss, inches of fluid flowing,
A = cross-sectional area, sq. in.,
Q = discharge, cu. ft. per sec.

In using Equation 1 to calculate the friction head loss due to liquid flow through the downspout, the minimum cross-sectional area normal to the path of liquid flow should be used. In some cases, downspouts are tapered at the bottom to facilitate the maintenance of a liquid seal. In other cases, the minimum cross-sectional area occurs between the bottom of the downspout and the lower plate, as for example with the downspout shown in Fig. 1, so constructed as to prevent vapor from the bubble caps from discharging into the downspout.

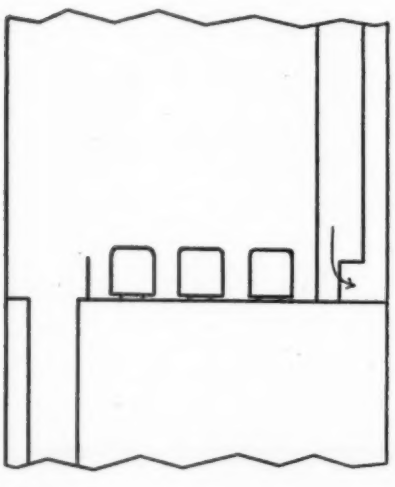


Fig. 1—Cut-away downspout to prevent vapors from the bubble caps from discharging into the downspout

As a rough design figure where there are no unusual constrictions the linear velocity of the liquid in the filled part of the downspout should be from 2 to 4 in. per sec. It is probably good practice to over design downspouts since they constitute a relatively unimportant cost item but are an important factor in flooding.

Bubble Caps

A bubble cap assembly consists of a chimney or riser, the cap which is mounted over the riser, and the means by which the cap is held in place. This is illustrated in Fig. 2 which shows an "exploded" view of a typical removable cast metal assembly.

While a large number of different types of caps are used, the most common type is the round, bell-shaped cap ranging in diameter from 2 to 7 in. The caps are often made of cast iron as shown in Fig. 3 or of sheet steel as shown in Fig. 4. Where necessary for corrosion resistance other materials are used, such as copper or nickel. The chief advantage of cast iron caps over steel caps is corrosion resistance, although this factor is not as important as might be thought since the major area of corrosion in a fractionating column is at the vapor-liquid interface at the shell. The chief advantage of sheet metal caps is that they are lighter and may be more closely spaced due to their smaller bulk.

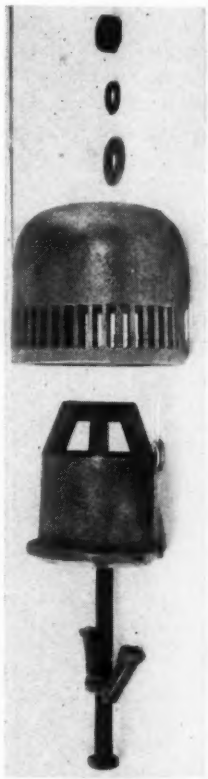


Fig. 2—Exploded view of a removable cast iron bubble cap assembly

Chimneys may be welded or brazed to the plate, or may be rolled, screwed or clamped into place. Sheet metal caps are often fastened over the chimneys by tack welding or riveting the skirts to the plate as shown in Fig. 5. Where it is desirable for maintenance purposes to have removable caps, they may be bolted to the plate by using a spider, or may be held down by means of trolley bars as shown in Fig. 6 or even by their own weight in some rather unusual cases.

Another type of cap which is common in the petroleum industry is the so-called tunnel cap which fits over rectangular chimneys from 3 to 6 in. wide and from 12 in. to several feet long. These caps are easy to install and to maintain because of the fewer parts involved. However, better plate efficiency, less entrainment, and less erratic performance is usually obtained with the round caps.

The spacing of the caps on a plate should be such as to give

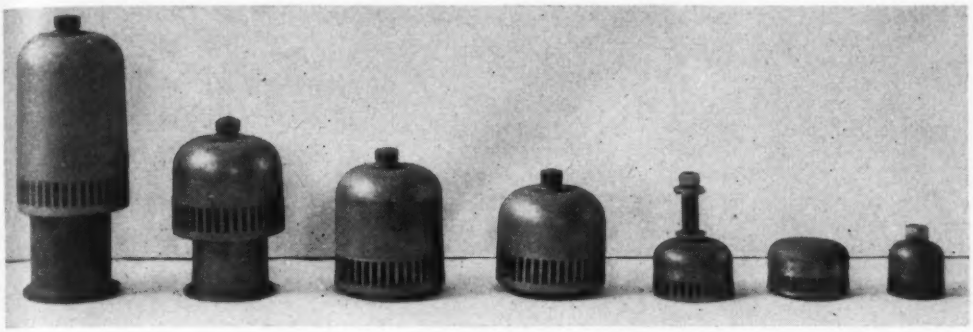
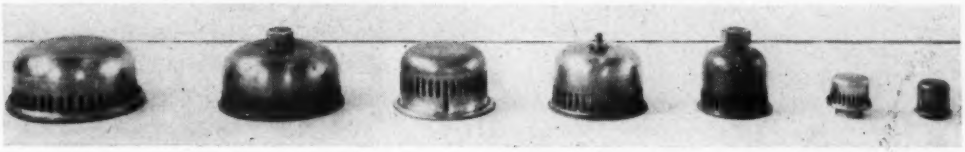


Fig. 3 (left)—Typical removable cast iron bubble caps

Fig. 4 (right)—Typical pressed sheet metal bubble caps



Photos (Figs. 2, 3, 4) courtesy E. B. Badger and Sons Co., Boston

ample turbulence to the liquid around the caps but not so close as to produce spouting or jetting between the caps. In general, caps are spaced on the vertices of equilateral triangles, usually giving a wall-to-wall distance between the caps of from 1 to 3 in. Particular care should be taken to avoid locating the caps too close to the weirs or downspouts because of spouting of the liquid over the weir into the downspouts, unsteady liquid flow over the weirs, and the possibility that vapors may discharge under the downspouts. It is sometimes desirable to blank off the slots in the sides of the caps nearest the downspouts. In small columns it may also be desirable to place baffle plates from the plate above in front of the exit weir to prevent splashing of liquid over the weir.

In general, the design of the cap is such that the area of the chimney is equal to the area of the annular space between the cap and the chimney. These areas are also approximately equal to the area of the slots. This relationship provides a path of uniform cross-section for the flow of vapors, and reduces to a minimum the pressure drop through the cap due to vapor flow.

The pressure drop through the bubble caps having rectangu-

Photo courtesy The Lummus Co., New York

Fig. 5—Riveting sheet metal bubble caps to bubble plate

Photo courtesy Struthers Wells Corp., Titusville, Pa.

Fig. 6—Tray for a 48-in. column, showing 6-in. cast iron bubble caps and trolley bars to hold caps in position

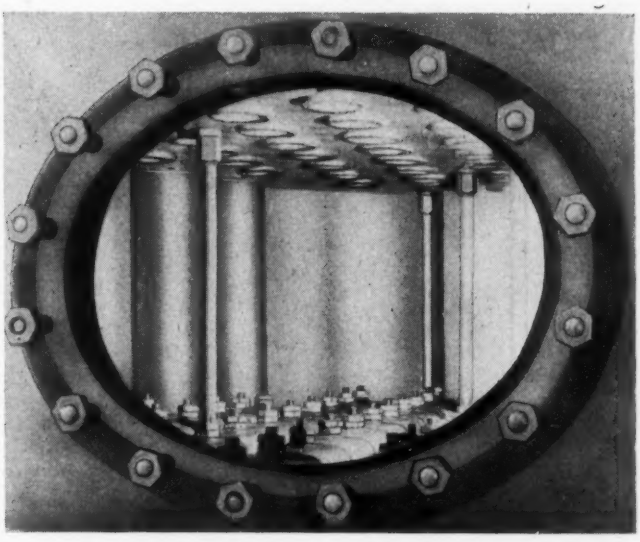


Photo courtesy Vulcan Copper and Supply Co., Cincinnati, Ohio

Fig. 7—Interior view of a cross flow plate showing circular downspouts and supporting members

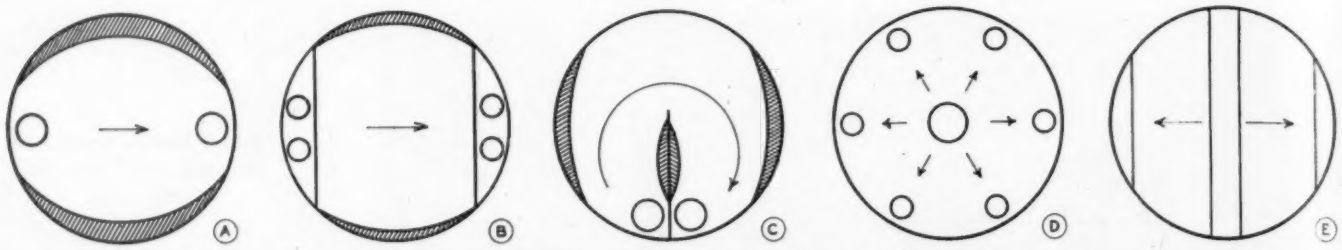
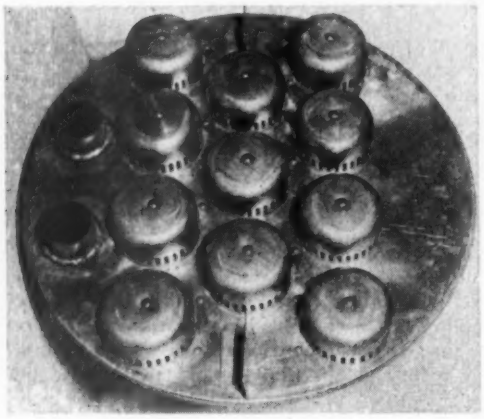
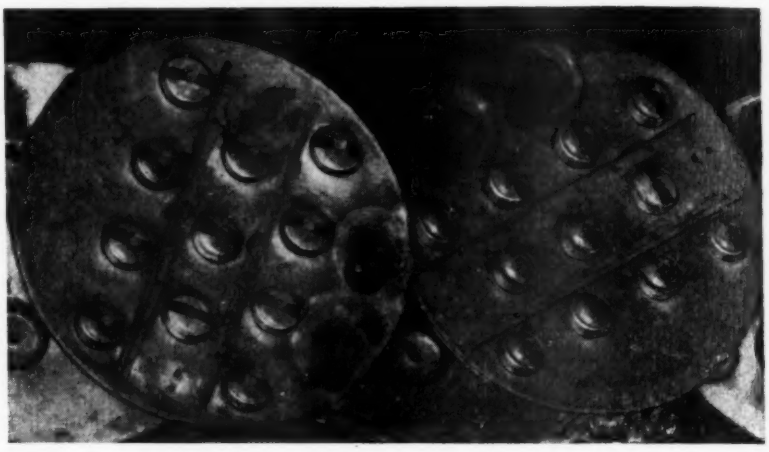


Fig. 8—Diagrammatic illustrations of several common types of bubble tray layouts. Shaded areas tend to become inactive as tower diameter is increased, because of by-passing of liquid





Photos courtesy The Lummus Co., New York

Fig. 9 (left)—Small bubble plate with simple cross flow arrangement
Fig. 10 (right)—Bottom view of type of plate shown in Fig. 9, showing downspouts and stiffening members

lar slots closed at the bottom and having a constant area of vapor path is given by the orifice equation[5].

$$h_{so} = 0.5\ \rho_v/\rho_1\ v^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

ρ_v = density of the vapor,
ρ_1 = density of the liquid,
v = vapor velocity, ft. per sec.

As a rough design figure, the velocity of the vapor passing through the risers and slots should range from 9 to 14 ft. per sec. for columns operating at atmospheric pressures and above. For vacuum columns, the pressure drop per plate becomes exceedingly important and all designs should be based on calculations of pressure drop across the plates.

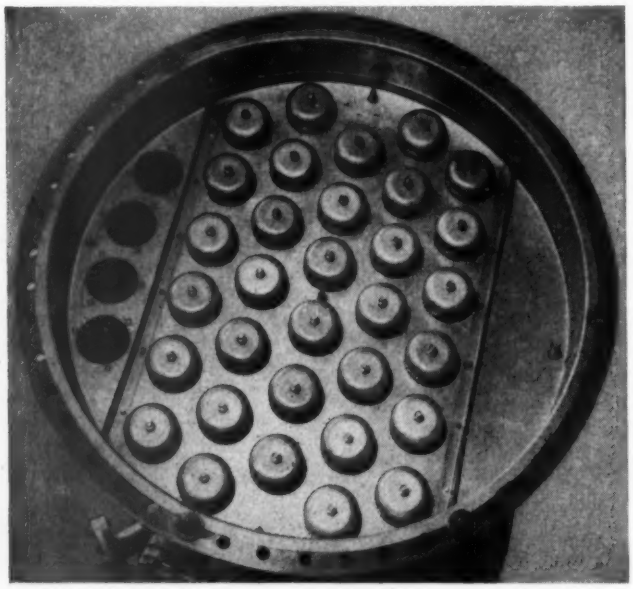


Photo courtesy Vulcan Copper and Supply Co., Cincinnati, Ohio

Fig. 11—Cross flow plate showing inlet and outlet weirs

Plate Spacing

The calculation of the various factors affecting the height to which liquid will back up into the downspouts permits a reliable estimation of the plate spacings which should be used. Since flooding is a very real danger under normal variations in the heat input to a column or feed variation, the plate spacings should be at least 200% of the calculated minimum[3]. Further, columns operating under plant conditions should have a calculated liquid back-up which is less than 60% of the tray spacing. With foaming liquids, even larger factors of safety should be employed. With well-designed trays the calculated liquid back-up may reach 80% of the spacing before flooding begins[3].

The present discrepancies between calculated flooding conditions and actual flooding conditions are probably due to the lack of information concerning the estimation of the amount of entrainment.

Other factors enter into plate spacing[5]. Columns which for various reasons are to be housed, are frequently designed with spacings of 12 in. Such columns are usually used for difficult separations involving a large number of plates where it is preferable to minimize height at the expense of cross-section. Where columns may be placed outdoors the column height is no longer of prime importance and the plate spacing is usually set at 24 in. or more in order to allow for the installation of manholes on each plate, as shown in Fig. 7, an important maintenance feature, since it permits the use of cheaper materials of construction.

In general, the cost of increased height and smaller cross-section as compared to lower heights and wider cross-section is more than compensated for by the greater flexibility of the column. At large spacing overloads can be absorbed without

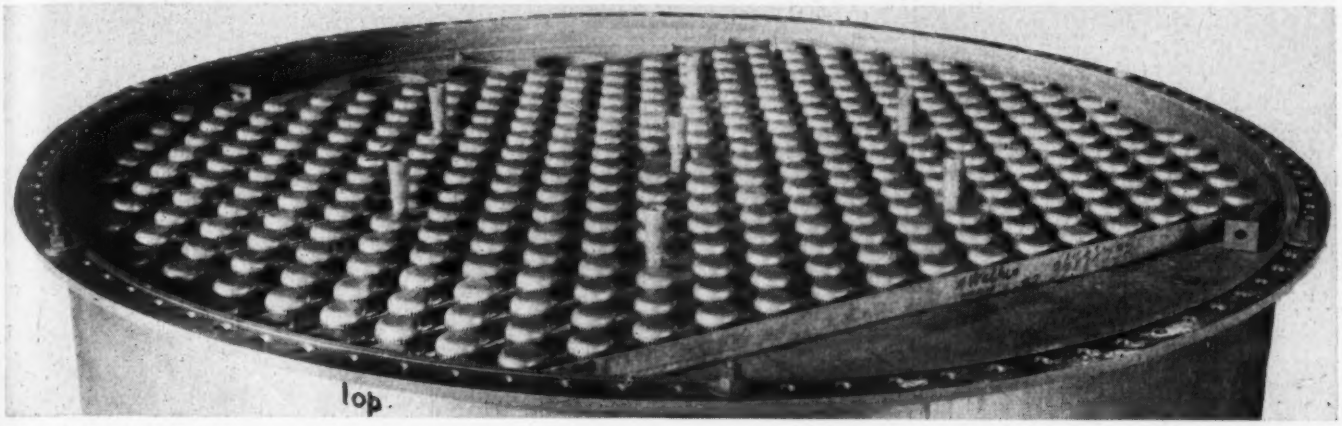


Photo courtesy E. B. Badger and Sons Co., Boston

Fig. 12—Large cross flow plate assembly in column section for alcohol distillation, showing supporting members, weirs and handling lugs

serious consequence, whereas with low plate spacing careful attention must be paid to conditions which might produce flooding.

Tray Layout

Two important considerations govern tray layout. The layout should be such as to avoid short circuiting of the liquid flow across the plate which reduces the effectiveness of the bubble caps not in the direct line of flow. The layout should also avoid building up of excessive liquid level differentials across the plate which cause the greater proportion of the vapors to pass through the caps having relatively low liquid seals. This condition produces spouting and excessive entrainment at the caps with low liquid seals while the caps on the other side of the plate may be entirely inactive. In general these two difficulties are opposite in their effect on tray layout since layouts which tend to produce even distribution of liquid flow across the plate may produce excessive liquid differentials.

Fig. 8 shows several of the common tray arrangements diagrammatically. As tower diameter is increased the area of the tray which is shaded tends to become inactive because of bypassing of liquid. Fig. 9 shows a simple cross-flow arrangement with circular downspouts also serving as weirs. Fig. 10 shows the bottom of these plates with stiffening members and downspouts. These plates are welded into the column sections. This arrangement is satisfactory for relatively small columns up to 2½ to 3 ft. in diameter.

For columns in the range of 2 to 6 ft. in diameter it is preferable to include an exit weir as indicated in Fig. 8-B and as shown in Figs. 11 and 12.

The baffles shown in Fig. 9 eliminate the dead space between the ends of the middle row of caps and the walls. For larger columns, if satisfactory cross-flow distribution is to be obtained it is necessary to eliminate a disproportionately large amount of tray space in order to include a sufficiently long wedge type weir. This leads to the use of the arrangements such as are indicated in Figs. 8-C, 8-D, and 8-E.

The use of the arrangement shown in Figs. 8-C and 13 is quite satisfactory from the point of view of liquid distribution. However, this arrangement sharply increases the length of the liquid flow path and therefore tends to produce excessive liquid head differentials across the plate. An important precaution in this arrangement is the removal of some of the caps at the end of the baffle in order to avoid undue constriction of the liquid path at this point. This is well illustrated in Fig. 13.

A common arrangement used in large columns is the radial flow types shown in Fig. 14 and 15. On these plates the liquid may flow to and from the center on alternate plates or, by the use of seal caps and suitable conduits from the downspout, may be made to flow in the same direction on all plates as shown in Fig. 15.

In exceptionally large columns, such as shown in Fig. 16,

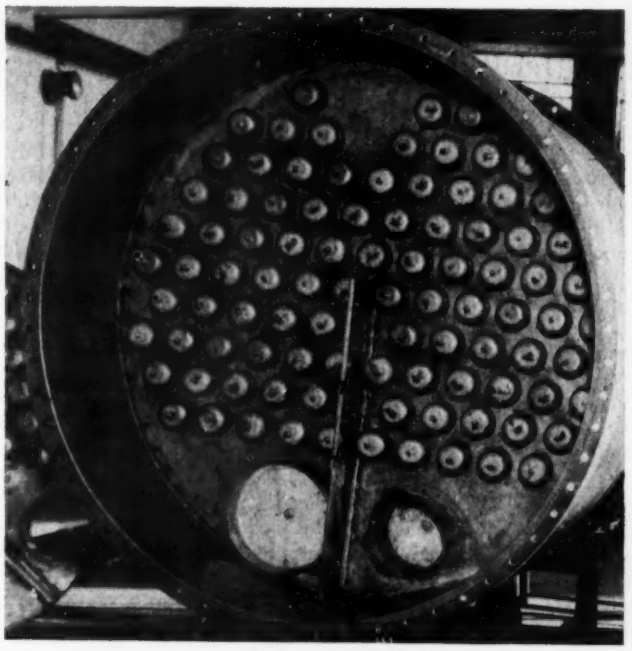


Photo courtesy The Lummus Co., New York

Fig. 13—Large tray showing baffle arrangement for liquid distribution. This arrangement is similar to that shown in Fig. 8-c

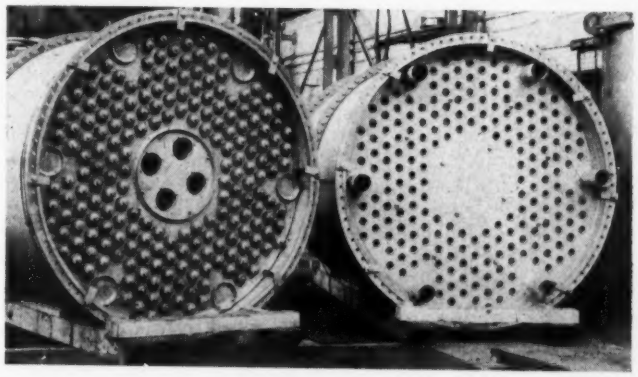


Photo courtesy Vulcan Copper and Supply Co., Cincinnati, Ohio

Fig. 14—Large radial flow type of tray

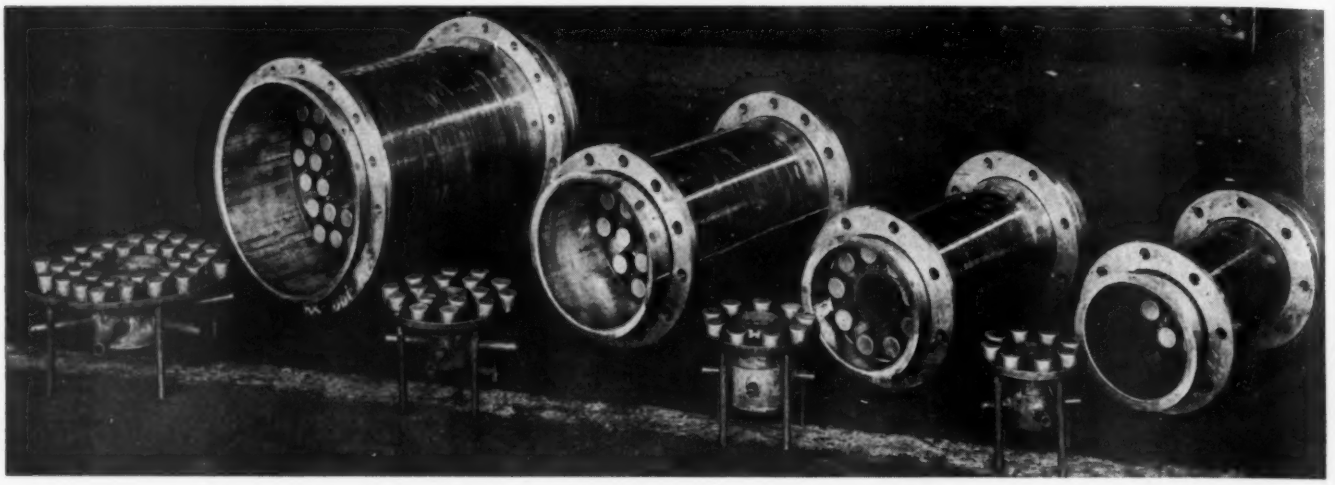


Photo courtesy Struthers Wells Corp., Titusville, Pa.

Fig. 15—Sections of columns for fractionating gases at very low temperatures, nickle steel construction

the arrangement illustrated in Fig. 8-E is effective when combined with the feature of cascades. Cascades are used to maintain the liquid seal over the caps constant in spite of considerable liquid head differential across the plate and consist of a series of different levels in the tray itself, the liquid level in each section being maintained by means of a weir.

Another procedure which is sometimes of great help in avoiding the deleterious effect of liquid build-up across a plate is the deliberate use of bubble caps which have a relatively high friction head loss. By increasing the proportion of pressure differential through the bubble caps relative to the total pressure drop in the path of the vapor stream, the effect of liquid build-up in producing by-passing of the vapors through a portion of the caps may be largely eliminated. Naturally this expedient may not be used where total pressure drop through the plates is an important factor. Further, its use requires that additional plate spacing be provided because of the greater height of liquid which is produced in the downspout.

It has been shown by Good, Hutchinson and Rousseau[2] that the liquid build-up on a plate is reduced by increasing the liquid level on the plate and by increasing the skirt clearances of the bubble caps. The liquid build-up is increased by increased vapor velocities and liquid flow rate, and by an increased number of rows of caps across the path of the liquid flow. It is also directly proportional to the cap concentration, i.e., the number of caps per unit column cross-section.

These relations are correlated in Fig. 17, which plots the liquid build-up in inches of water as a function of vapor velocity, vapor density, cap concentration, liquid seal, and skirt clearance. For this chart liquid seal is defined as the depth of clear liquid above the top of the bubble cap slots at the overflow weir (minimum seal) and h is the liquid build-up across the plate in inches of water, based upon a flow of 1000 gals. of fluid per hr. per ft. of width for a plate containing 12 rows of caps across the path of liquid flow. The width of a circular bubble cap plate is taken as the arithmetic average of the width of the plate at the longest and shortest rows of caps.

In using the figure, N is the number of caps per unit column cross-section and the term 7.14 is a correction factor to account for the fact that the experimental data for the correlation were obtained from a plate which contained 7.14 caps per square foot of column cross-section. To calculate the build-up across a tray containing n rows of caps across the plate and having a liquid rate of one gal. per hr. per ft. of width, the value of h_1 read from Fig. 17 would be corrected to the actual conditions by the following equation.

$$h = h_1 \frac{\text{gals. per. hr./ft.}}{1000} \times \frac{\text{No. of Rows}}{12} \quad \ldots\ldots\ldots\ldots (3)$$

This correlation, in effect, gives the pressure drop across the plate in the units "inches of water." Thus, where the fluid on the plate is not water, a density correction must be applied to the build-up to calculate the actual increase in the height of liquid across the plate. In calculating the build-up, it is neces-

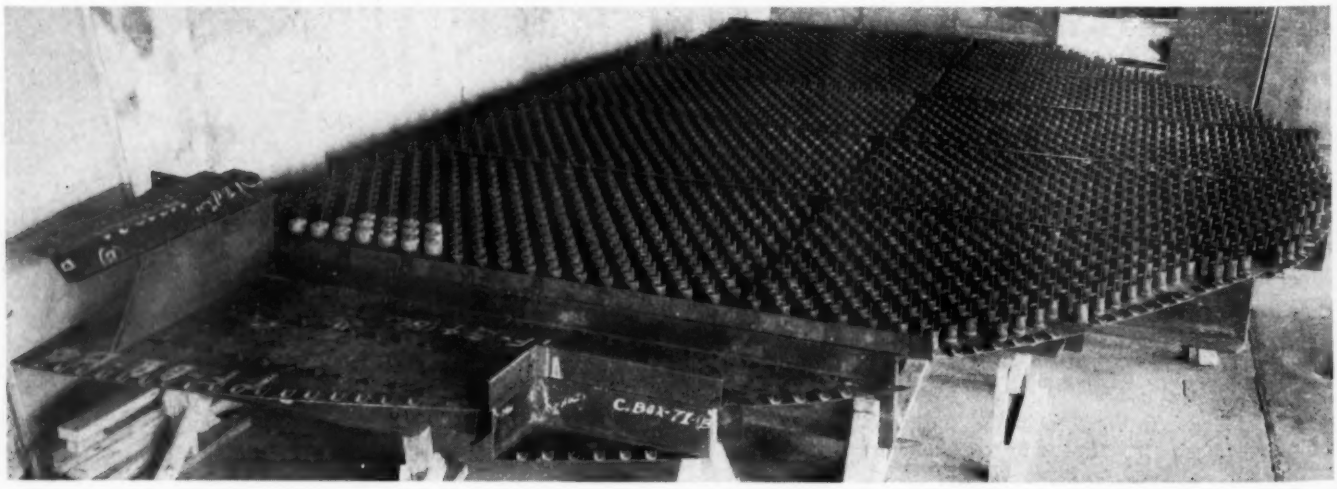


Photo courtesy Fritz W. Glitsch & Sons, Dallas

Fig. 16—A section of a cascade type tray for a 33-ft. diameter column, each tray of which contains over 5000 4½-in. caps

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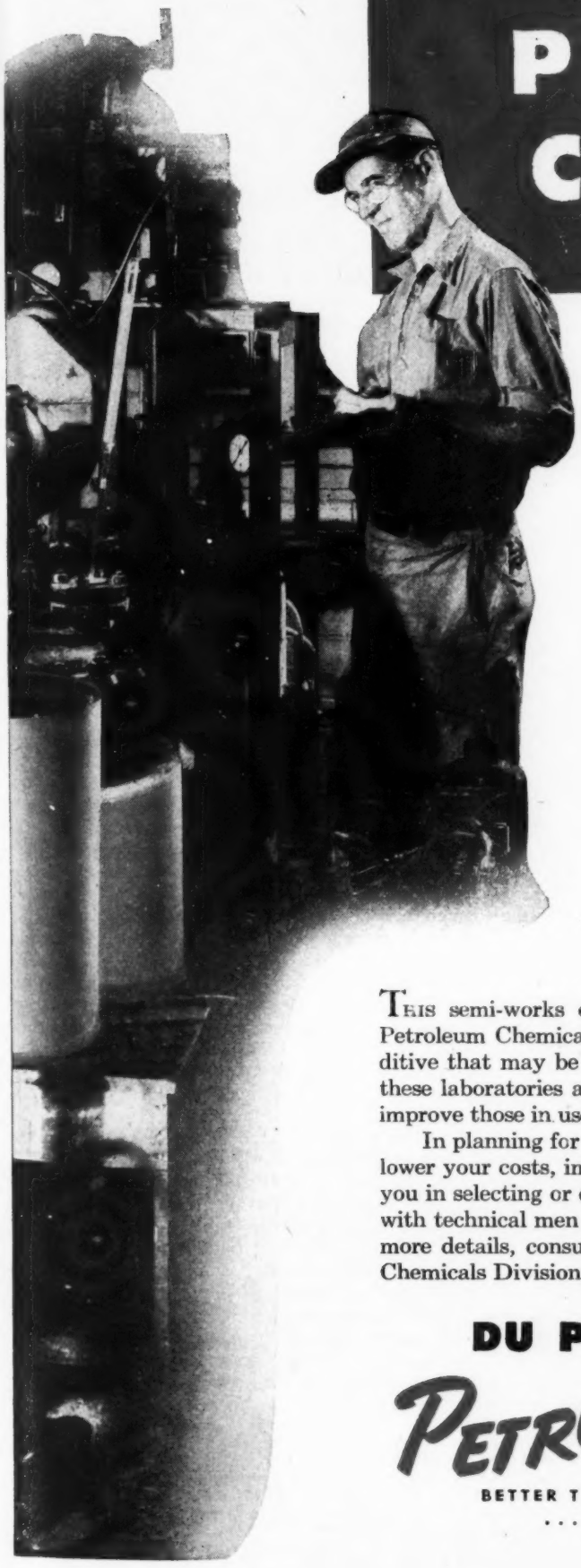

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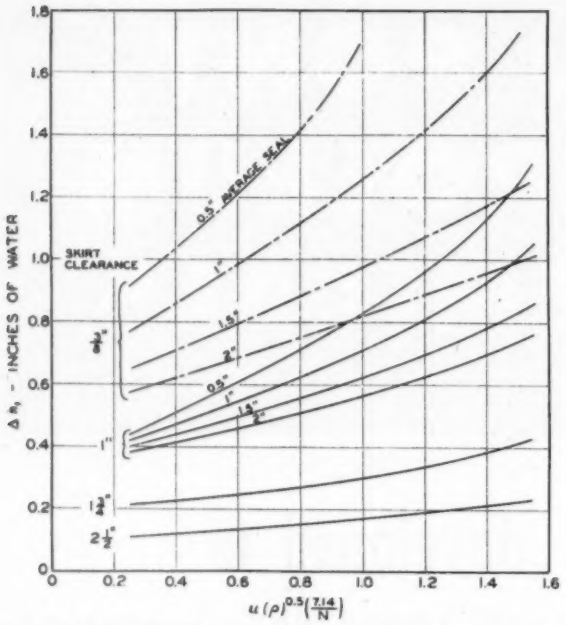


Fig. 17—Correlation of liquid heat differentials across bubble caps[2]

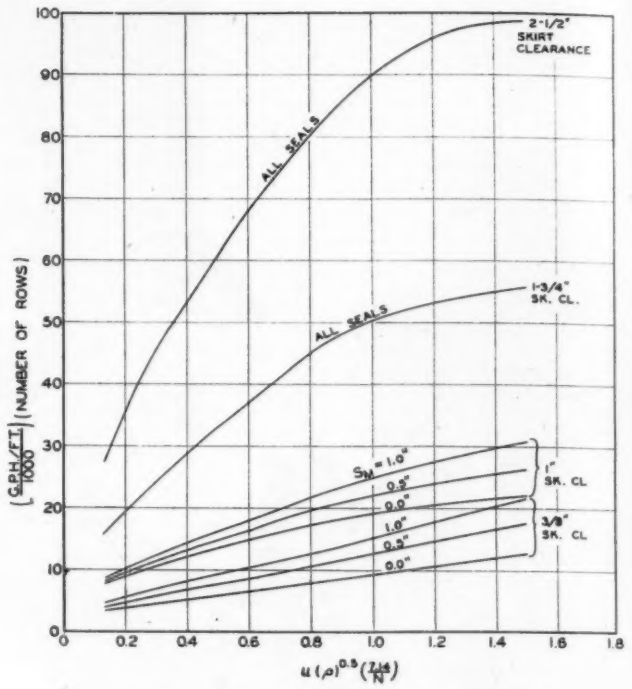


Fig. 18—Correlation of plate stability[2]

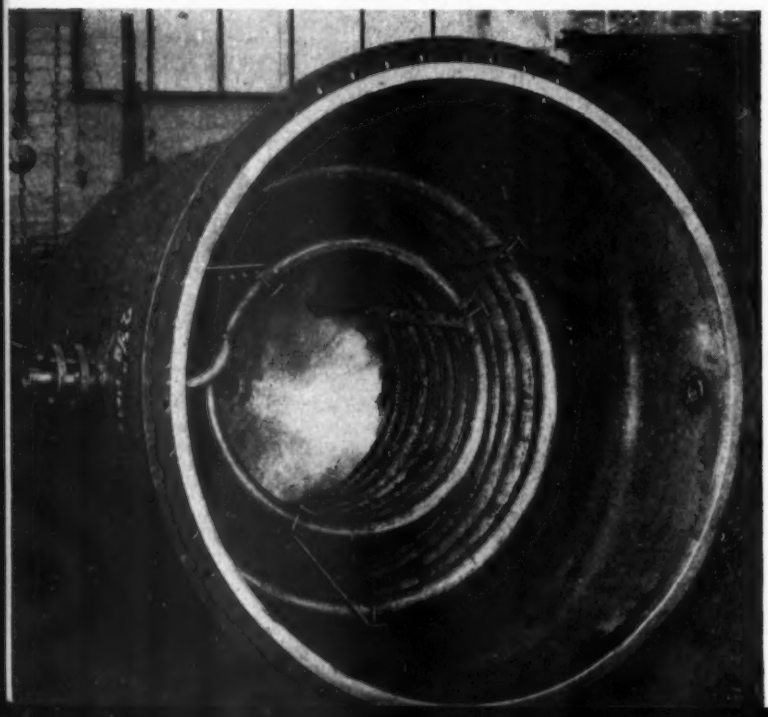
sary first to assume a build-up in order to estimate the value for the average seal, S_{av}. The build-up calculated from the estimated average seal should check the value for build-up assumed. Usually only one or at the most two trials are necessary in making this calculation.

A stable plate is defined as one on which all of the caps are active. Fig. 18 correlates the maximum liquid flow rates at which stability is maintained as a function of vapor velocity, vapor density, cap concentration, minimum seal, and skirt clearance.

The stable operation of a plate (a plate on which all caps are active) does not necessarily mean that it is operating at maximum efficiency but does insure against operation at poor efficiencies and thus affords a valuable check on column operation. As a rough design figure, liquid runs of more than 6 ft. should be avoided unless suitable precautions such as cascades or variable cap levels are taken.

Fig. 19—Bottom section of 4-ft. column showing heating coils

Photo courtesy S. Blickman, Inc., Weehawken, N. J.



Reboil Heat

Heat may be supplied to the base of a fractionating tower in many ways, the most common being (1) heating coils installed in the bottom section of the column, as shown in Fig. 19, (2) an external heat exchanger operated by means of a hot stream of liquid and (3) an external direct fired tube still through which liquid from the bottom of the tower is pumped at high velocities.

Where the material at the base of the column is sensitive to temperature, the use of steam condensing inside of a closed coil in the base of the column is a convenient method since the maximum temperatures which may be obtained are limited by the pressure of the steam. The chief limitation of this method is in the temperatures which may be attained conveniently by the use of steam. In order to overcome this difficulty Dowtherm or similar fluids may be used.

The petroleum industry often uses hot oil streams which are relatively easy to obtain to heat the material from the base of light hydrocarbon fractionating towers in external tube and shell or double pipe heat exchangers. The exchanger is arranged so that circulation of the liquid from the bottom of the tower through the exchanger is obtained by thermal convection. The mixture of liquid and vapor is returned to the base of the column, the liquid recirculating through the exchanger and the vapor passing upwards through the tower.

Where a direct fired tube still is used to heat a stream from the bottom of the column it is usually necessary to pump the liquid at high velocity through the tubes in order to avoid "skin" cracking of the liquid. In some instances, with stable materials, direct fired thermal convection furnaces have been used, as in rerunning operations.

The installations of reboiling equipment require precautionary measures against flooding since in many cases the maximum liquid load occurs at the reboiler, and inadequate handling capacity at this point may cause the beginning of flooding in the rest of the tower[3].

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PERSONALS

Petroleum Technologists in the Headlines

The Cadman Memorial Medal for outstanding research in petroleum science has been awarded to **Robert P. Russell**, president of Standard Oil Development Co., and onetime head of the Esso Laboratories at Baton Rouge.

Mr. Russell

The Cadman medal is a British award given at least once every three years to people in the petroleum research industry, and will be presented to Mr. Russell on June 4 when he delivers the second Cadman memorial lecture in London. He will speak then on "Progress in Petroleum Research."

Mr. Russell began his career with Standard Oil Co. (New Jersey) as director of the newly established research laboratories at Baton Rouge. He pioneered the work of hydrogenation and has been associated with its advancement in this country.

In 1929 he became vice president and general manager of the Hydro Engineers & Chemical Co., a Standard of Jersey affiliate, and five years later vice president and general manager of Standard Oil Development Co.

Among other awards received by Mr. Russell are the Medal for Merit, the highest civilian award in the United States given to him by the Army for his work on pyrotechnics and the American Institute of Chemical Engineers 1946 Gold Medal for "noteworthy and outstanding service to the science of chemistry."

• • •

Lloyd R. Zumwalt has left the Shell Development Co. to join the staff of the chemical division for Monsanto Chemical Co. at the Clinton Laboratories, Oak Ridge, Tenn.

• • •

W. Earl Dunn, The Fluor Corp. and **E. W. Walker**, Western Gulf Oil Co., have been elected to fill the two vacancies on the Board of Directors of the California Natural Gasoline Association.

Both men have long been associated with the petroleum industry. Mr. Dunn started with the Midway Oil Co., after his graduation from Michigan College of Mines and later spent a year with the California Gasoline Co. In 1926 he joined the natural gasoline division of the Richfield Oil Corp., and in 1930 became associated with the Fluor Corp., of which he is now vice president and general manager. He has supervised the design and construction of many gasoline plants, refineries and gas compressor stations.

Mr. Walker graduated from Stanford University and after a brief stay with General Electric Co., at Schenectady, returned to California and worked for Kettleman Hills Dome Assn. In 1934 he became associated with the Western Gulf Oil Co., as a mechanical engineer at the Bakersfield office. Mr. Walker recently has been transferred to Los Angeles and placed in charge of the chief engineer's office.

• • •

Francis C. Savage, former assistant technical director of Magnolia Petroleum Co., has been placed in charge of coordinating the lubricating oil blending and compounding activities of Socony-Vacuum Oil Co., Inc.

Mr. Savage

Mr. Savage will also handle special assignments in the manufacture of lubricating oils. He is known to petroleum chemists and engineers as a contributor of interesting articles on lubricating oil manufacture.

• • •

W. Elick has been promoted from maintenance foreman at the Torrance plant of the Shell Chemical Corp. to senior engineering inspector at the Houston plant.

Also, another change announced, was for **R. E. Hughes** who becarre senior engineering inspector at Houston. He was formerly an engineer at the Torrance plant.

• • •

Promotions announced at the Emeryville plant of Shell Development Co., included **James M. Mullen**, to assistant chief engineer in the engineering department and **Fred M. Nelsen, Jr.**, laboratory assistant to junior chemist.

• • •

Charles F. Weinaug has accepted a position as associate professor of petroleum research and engineering at the University of Texas. He formerly was with the research staff of Phillips Petroleum Co.

• • •

E. Duer Reeves has become director of research and development for the Standard Oil Development Co., at New York.

• • •

John P. Allen has been appointed process superintendent at the Baltimore refinery of Standard Oil Co. of New Jersey, succeeding **Herman G. Gunther**, who has been transferred to Billings, Mont., with the Carter Oil Co.

• • •

L. H. Butterworth has been promoted to assistant general superintendent of Standard of Indiana's Casper, Wyo., refinery. He was assistant general foreman at the company's Whiting refinery.

Mr. Butterworth joined Standard of Indiana in 1937 as a chemical engineer in the research department at Whiting. In 1942 he came to the manufacturing department as assistant general foreman.

• • •

Dr. Richard N. Meinert has been named assistant chief of research in the Tulsa laboratories of the Carter Oil Co. He has been engaged in research work for the past 10 years with the Standard Oil Development Co. at Bayway, N. J.

Dr. Meinert holds a Ph. D. in organic chemistry from Northwestern University and served on the faculty of Brown University before coming to Bayway as a research chemist.

• • •

Robert M. Cole has been succeeded as chief engineer of the engineering department at Emeryville for Shell Development Co., by **Richard L. Iglehart**, who was assistant chief engineer.

Mr. Cole was named head of Shell's experimental plants.

• • •

Dr. Monroe E. Spaght, vice president of Shell Development Co., addressed the American section of the Society of Chemical Industry last month on the "Future Research in Hydrocarbons."

Dr. Spagt

Dr. Spaght has been associated with the petroleum industry since 1933 and can be credited with many important chemical and engineering achievements. As a result of his extensive research efforts, the refining of petroleum and the manufacture of chemicals from petroleum hydrocarbons has become a highly developed organic chemical industry.

Looking to the future, Dr. Spaght predicted that our constantly increasing store of basic knowledge will make it possible for hydrocarbon technical development to proceed at a very fast rate. At the same time, scientific changes in other fields will continue to present new problems which will have to be solved by new research and technology.

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Personals

James W. Aires has been named assistant general foreman of the crude distillation division for the Baltimore refinery of Jersey Standard.

* * *

M. Wesley Rigg has accepted a position on the faculty at Temple University, Phila. He was formerly with the Shell Development Co.

* * *

Ray E. Luton, who started at the Ohio Oil Co. as assistant superintendent and chemical engineer in 1924 has been appointed manager of refineries for the company.

Mr. Luton has been general superintendent of refineries and will have his headquarters at Robinson, Ill. for the present. He will have overall supervision of the refineries at Robinson, Ill. and Lovell, Wyo.

He is a member of the Board of Trustees of the Western Refiners Association and the 25 Year Club. He is also a member of the American Society for Testing Materials, and during the war served on various District Two Petroleum Industry Refining Committees.

* * *

F. S. Wood, of Standard of Indiana's Whiting refinery, has been placed in charge of the lubricant group of the engine research laboratory.

Other promotions announced at the Whiting refinery were E. L. Gregory to mechanical supervisor of the engine laboratory and Dr. J. C. Bailie to assistant chief chemist.

* * *

Frank J. Spuhler has been named foreman of the isobutylene-extraction units of the butyl-rubber plant of Humble Oil and Refining Co.

* * *

Richard M. Gooding, petroleum chemist in the Bureau of Mines experimental station at Bartlesville, Okla., has been transferred to the bureau's main offices in Washington to serve as assistant to the chief engineer in charge of petroleum chemistry and refining matters.

Mr. Gooding joined the bureau in 1941 and during the war worked on the development of analytical methods for evaluating components of aviation fuels.

* * *

Russell H. McGuiney has been promoted to field engineer of Ethyl Corp., Philadelphia.

Correction

The flow diagram (Fig. 1) with the article entitled "Inexpensive Aeration Tanks Handle Disposal Problem" in the February issue of PETROLEUM PROCESSING, pg. 102, had the "Recovered Emulsion" going to the "River". This line should have shown the "Recovered Emulsion" going to "Treatment".

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Explains the major uses of electronic tubes and phototubes, and the construction of electronic devices and working principles . . . Deals with the constitution of matter—including discovery of the electron; the flow of electricity; radio communication—covering the function of vacuum tubes, reception of radiated energy and amplification; reproduction of sound and pictures; modern sources of light—describes the methods by which various types of lighting equipment operate; and diverse applications of electronics—including the electron microscope, radiosonde and medical electronics . . . Of special interest to the petroleum man is the application of electronics to industrial and chemical work—such as the electron microscope and the various types of lighting equipment and how they work . . . 97 pages, 5¾ x 8¾ . . . Illustrated and Indexed $3.00

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Personals

F. D. Juenzly, Jr., senior technologist of Shell Chemical Corp. in San Francisco, has been promoted to assistant plant superintendent in Houston.

* * *

W. Howard Snyder at the Baltimore refinery of Standard of New Jersey has become general foreman of the cracking and rerunning division.

* * *

A member of the research staff since 1936, **John B. Duckworth**, has been named an assistant director of research for Standard Oil Co. (Ind).

* * *

A. C. Matthis, has been announced as the new head of the engineering section of the petroleum technical-service department at the Baton Rouge refinery of Standard Oil Co. of New Jersey, Louisiana Division.

* * *

Promotions were announced in the inspection department of the Baton Rouge refinery of Jersey Standard, Louisiana division, for **A. F. Blumer, J. C. Mitts** and **O. C. Day**. They were named the heads of the refinery-inspection groups. **C. S. Pugsley** became assistant head of the equipment inspection section at Baton Rouge.

* * *

Sumner H. McAllister, associate director of the experimental plants for Shell Development Co., at Emeryville, has been named associate director of petroleum technology for the company.

* * *

F. A. Hannaman, Jr. has been named head of a project-coordination group of the mechanical-engineering department at the Baton Rouge, La., refinery of Standard Oil Co. of New Jersey, Louisiana division.

O. R. Menton has taken over supervision of the group in the same department.

* * *

Frank Jones has been named to general shift foreman for the Baltimore refinery of Standard of New Jersey.

Annual Index Ready

The annual index of articles published during 1946 in PETROLEUM PROCESSING (Sept.-Dec.) and the NPN *Technical Section* (Jan.-Aug.), its predecessor, is now ready. It gives a complete subject and author listing of all material appearing during the year in the two magazines. Copies of the index can be obtained, without charge, upon request to:

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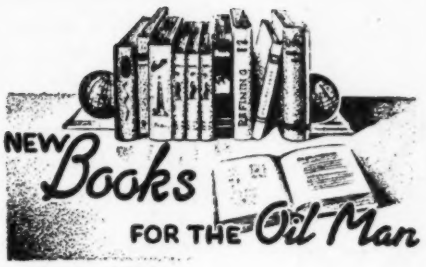

New Chemical Dictionary Joins Growing List of Reference Books

Concise Chemical and Technical Dictionary, edited by H. Bennett, 6 x 9 in., 1120 pages, stiff cloth binding, indexed, $10.00.

A new addition to the growing list of reference books in the field of chemistry, the *Concise Chemical and Technical Dictionary* contains a great many internationally accepted terms which facilitate mutual understanding among scientific and technical workers of many countries.

A special feature is an up-to-date compilation of thousands of trade names in the synthetic resin, plastics, metal, rubber, textile, food, pharmaceutical, paint and varnish fields, including emulsifying and wetting agents, plasticizers, detergents, and the like.

An up-to-the-minute Addenda in the back of the book lists the newest trade names and definitions of additional technical terms.

Editor Bennett is technical director, Glyco Products Co. Inc., member of many scientific societies, and editor of *The Chemical Formulary*, *Practical Emulsions*, and *Commercial Waxes*.

Latest Edition of ASTM Standards Includes New Specifications

A. S. T. M. Standards on Petroleum Products and Lubricants, prepared by A.S.T.M. Committee D-2, 6 x 9 in., 615 pages, heavy paper binding, illustrated, indexed, $4.00 (Dec., 1946).

In addition to some 130 ASTM test methods, specifications, and definitions of terms relating to petroleum and petroleum products, this latest compilation by Committee D-2 includes three proposed tests published in draft form to elicit constructive criticism and comment. These tests cover sulfated residue of lubricating oils, phosphorus in organic materials, and aromatic hydrocarbons in mixtures with naphthenes and paraffins by silica gel absorption.

This new edition has been considerably expanded by the inclusion of numerous specifications covering aromatic hydrocarbons—various grades of benzene, naphthas, toluenes, and xylenes.

Many of the test methods are issued in their revised form, and a number of the procedures are new. Those carrying 1946 dates, which indicate either revisions or issuance for the first time in 1946, include methods for determining acid and base numbers, aniline and mixed aniline points, dielectric strength (insulating oils), and foaming characteristics of crankcase oils. Others relate to inorganic chlorides and sulfates in insulating oils, knock characteristics of aviation fuels, determining certain insolubles in used lubricating oils, and the analysis of petroleum sulfonates.

The publication has been issued annually since 1927 under the auspices of ASTM Committee D-2.

Copies of all books reviewed here may be ordered from the Reader's Service Department, Petroleum Processing, 1213 West Third St., Cleveland 13, for the prices listed, postpaid, unless indicated otherwise. Ohio purchasers please add 3% tax.

"Helpful Trade Literature" items are usually available without charge, and can also be secured from the Reader's Service Department of Petroleum Processing.

API Publishes 1945 Papers On Production Practice

Drilling and Production Practice, 1945, Production Division, American Petroleum Institute, 8 x 10½ in., 212 pages, stiff cloth binding. $2.50. (1946).

This new volume contains papers on drilling and production practice selected by the Program Committee of the API Central Committee on Drilling and Production Practice from papers prepared and released for publication, or prepared and presented at national or district meetings of the Production Division during 1945.

The papers are grouped in three sections covering production practice, materials, and miscellaneous.

New British Oil Book Surveys Present Status of Technology

Modern Petroleum Technology, 6 x 9 in., 466 pages, stiff cloth binding, illustrated and indexed, $4.75 (1946).

More of a survey of the present stage of technological development in the petroleum industry than a detailed technical treatise, *Modern Petroleum Technology* is a new publication of the Institute of Petroleum in London which gives a broad picture of the entire field of operations.

With each chapter written by separate authors, it is intended to make available the knowledge of those expert in one field to those engaged in the other branches of the industry. The book includes some of the most important advances made in war time that have been released for publication. About a third is devoted to a discussion of refining, another third to uses for petroleum products of all types, and the balance covers exploration, drilling, production, transportation and distribution, and economics.

The majority of the chapter authors are British engineers and oil technologists. However, the discussion on cracking was written by the American, Gustav Egloff. It is the aim of the Institute of Petroleum to maintain the book in keeping with its title by issuing revised editions from time to time.

Helpful Trade Literature

Organic Nitrogen Compounds, a 31-page booklet presenting in detail the properties, specifications, and uses of the alkyl amines, alkylene amines, alkanolamines, and acetoacetarylamides. In chart form it gives their physical constants, comparative hygroscopicities, and neutralization curves. These compounds are useful in many industries as emulsifiers, and neutralizers, and are used in synthesizing, dissolving and saponifying. Newer uses for amines include petroleum emulsion breakers, gasoline additives, and catalysts. Carbide and Carbon Chemicals Corp., 30 East 42nd. St., New York 17, N. Y.

Automatic Temperature Control Systems, Educational Bulletin No. 5, includes charts, tables, and diagrams explaining measurement and automatic control and the selection of proper control systems for process applications. A separate section is devoted to thermocouples. The Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

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EDITORIAL COMMENTS

WIDENING HORIZONS

Again Issue of Control of Science Foundation Is Before Congress

PROPOSALS for a National Science Foundation to coordinate research effort in the interests of public welfare and national defense are already before the new Congress in the form of bills in the Senate and the House. Just as in the last Congress the bills represent the divergent views of two groups as to where the responsibility shall rest for the direction of any all-inclusive research program undertaken.

Senate Bill 525, introduced Feb. 7 by Thomas of Utah, calls for the "establishment of an independent agency of the Federal government headed by an Administrator appointed by the President." The Foundation thus created would have various divisions, each headed by a Director appointed by the Foundation Administrator. The bill creates an advisory National Science Board, consisting of nine members appointed by the President and the chairmen of the seven divisions of the Foundation. Nothing is said in the bill as to the qualifications of the appointed members of the National Science Board other than that they shall be "persons especially qualified to promote the broad objectives of the act". The proposals in this bill are the same as in S. 1850, the Kilgore bill, which was passed last July by the Senate only to die in the House for want of action.

Senate Bill 526 on the other hand is sponsored by the group including Senator Magnuson of Washington whose legislative proposals from the start have sought to embody in the main the views of Dr. Vannevar Bush, director of the Office of Scientific Research and Development, and a group of the leading scientists of the country. Dr. Bush was asked by President Roosevelt to recommend a program for government sponsored research. He and his associates made their report in the summer of 1945.

The premise of the Bush program in brief is that there now exists in the various government departments many groups whose interests are primarily those of scientific research with concrete objectives; and that basic research of the type required in the proposed new program could best be directed by an entirely independent agency devoted to the support of scientific interests and advanced education in general, responsible only to the President and to Congress.

This principle is recognized and embodied in S. 526 (and its counterpart is before the House) by the creation of a National Science Foundation of 48 persons. While the members of the Foundations are to be appointed by the President, their qualifications are well defined in the bill. They are to be (1) recognized leaders in the fields of the fundamental sciences, medical science, engineering, education or public affairs; (2) selected solely on the basis of established records of distinguished service and (3) so selected as to represent the views of scientific leaders in all parts of the country. Terms of members of the Foundation would be eight years.

Supervision of research activities of the Foundation by this bill would be vested in an executive committee elected bienially from its own members. The bill gives the Foundation broad and undefined authority to make expenditures and contract with agencies and institutions for the conduct of scientific research, reporting only to the President and Congress. There may justly be criticism of the entire lack of limitations on how and where government funds are spent by the Foundation, as proposed in S.526. However, the form of administration proposed would remove the program of the Foundation from exposure to political influence as far as is practical. This is an important objective in any type of research.

The ownership of patents resulting from government-financed research projects, as prescribed in the new bills, remains a point of difference between the two groups advocating a national science program. S. 526 provides for the disposition of inventions produced in a research project "in a manner calculated to protect the public interest and also the equities of the individual or organization with which the contract or arrangement is executed." The intent in S. 525 is that inventions produced in the course of federally financed research shall become public property.

Public interest in scientific matters of national import is running high and the chances are that legislation for a National Science Foundation will be enacted by this Congress. No need is seen for further long committee hearings. Oil company technologists who wish to express their views on the subject should act promptly.

Another Company Program Recognizes Contributions of Research Staffs

MORE ways are being developed by oil companies to compensate and reward members of their research departments for their scientific contributions on behalf of the company and also to stimulate the ambitions of the individual scientists to continue to study and advance in their professions.

Socony-Vacuum Oil Co. Inc. recently announced the establishment of educational grants to enable outstanding employes in its research laboratories to study for advanced degrees. One candidate, to be selected each year from the three company laboratories, will be granted leave of absence, with full pay, for a period not exceeding three years. Candidates must have a bachelor's degree and must be in Socony-Vacuum employ for at least two years to be eligible for the educational grants. Successful candidates will return to the employ of the company for at least two years after receiving their new degrees.

Candidates will be selected on the basis of fidelity to duty as well as ability and proficiency in science and inventiveness. A successful candidate may select the subject matter for advanced study and research as well as the school he desires to attend, subject to approval by the company. The candidate will be selected by a committee from Socony-Vacuum's technologists.

Programs such as the above meet needs which are inherent with research and development divisions of the oil companies. Public recognition of the work of the technologist often provides all the stimulus needed for study to keep up with the advances in his profession. Assurance by the company that compensation will be in line with scientific contributions will maintain the interest of men in straight research work if that is where they are best qualified. All told, such programs serve as an effective buffer against the arguments of organizers trying to bring the technical staffs—scientists, technical assistants and office workers pooled together—into a local of the outside labor unions.

READERS' comments and opinions will be welcomed by the editors of PETROLEUM PROCESSING, 1213 West Third Street, Cleveland 13, Ohio

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10° C	53.8
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